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A Cost-Benefit Analysis of Shipboard Telemedicine

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Telemedicine (TM) is an umbrella term that covers various technologies used to transmit information for health services. TM uses electronic information and communication technologies to provide and support health care when distance separates the participants. In an effort to enhance medical services at sea, the Navy is considering taking TM beyond the demonstration phase by installing the equipment on over 300 ships and Fleet Marine Force units. Because this would be a significant investment, the Surgeon General has asked CNA to determine the cost-effectiveness of the technology. We conducted a cost-benefit analysis on four telemedicine modalities: telephone and fax, e-mail and internet, video-teleconferencing, and teleradiology. These TM modalities can be enhanced with various digitized diagnostic instruments. We also conducted a cost-benefit analysis on the following instruments: dermascope, ophthalmoscope, otoscope, stethoscope, endoscope, electrocardiogram and defibrillator, and ultrasound.

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Summary

Background

Telemedicine (TM) is the use of communication technologies to support health care when distance separates the participants. It allows the transfer of medical information between platforms at sea and medical facilities ashore. To enhance medical services at sea, the Navy is considering installing TM equipment on over 300 ships and Fleet Marine Force units. Because this would be a costly investment, the Surgeon General has asked CNA to determine TM's cost-effectiveness.

We conducted a cost-benefit analysis on four telemedicine modalities: telephone and fax, e-mail and internet (for transmission of text with and without attachments, and videos in "store and forward" mode), video-teleconferencing ((VTC) for real-time video), and teleradiology (a film X-ray machine and a digitizing scanner). These TM modalities can be enhanced with various digitized diagnostic instruments. We also conducted a cost-benefit analysis on the following instruments: dermascope, ophthalmoscope, otoscope, stethoscope, endoscope, electrocardiogram and defibrillator, and ultrasound.

Our analysis is based on a survey of MEDEVACs distributed by the Fleet Surgeons to the ships' medical staff. The overall response rate to the survey was slightly above 50 percent (62 out of 120 requested ships). Our analysis is also based on data of over 13,000 ship medical encounters. We assembled a panel of Navy medical experts with experience using TM to review the medical encounters data. The panel estimated the man-day savings and quality of care enhancements that TM would produce.

Findings

What is the potential demand for telemedicine?

We estimate that if TM equipment were available to the entire fleet, ship medical staffs would initiate over 18,500 TM consults in a year. This translates to about 7 percent of all medical encounters. TM could potentially enhance quality of care for about two-thirds of these consults.

What would be the savings from avoided medical evacuations?

We estimate that Navy ships evacuated 911 patients during the year. Large ships perform a significantly greater number of MEDEVACs than small ships. During the period, carriers and amphibious ships evacuated an average of 23 and 10 patients (of their own crew), respectively. Small ships and submarines, on the other hand, evacuated an average of only 1 patient.

We found that 17.2 percent of the MEDEVACs are preventable with TM and are conducted on dedicated transport. This translates to about 155,000 travel miles in a year. We estimated that MEDEVACs cost an average of $4,400. Over half of this cost results from fuel and maintenance; the rest comes mainly from personnel pay.

On carriers and amphibious ships, the four modalities of TM would produce significant (aircraft and ship) fuel and maintenance savings resulting from avoided MEDEVACs. On small ships and submarines, however, the potential for fuel and maintenance savings is limited.

What would be the man-day savings?

On carriers and amphibious ships, all modalities of TM would generate significant man-day savings. On small ships and submarines, e-mail and internet would produce the most man-day savings, and VTC would generate very modest man-day savings. Teleradiology would produce no or very limited man-day savings on small ships and submarines.

Does TM improve quality of care?

E-mail and internet would have a significant favorable impact on quality of care on the different platforms. The percentage of e-mail and internet consults that would result in improved quality of care for sailors ranges from 32.5 percent for amphibious ships to 14.3 percent for submarines.

VTC, in contrast, would have very little impact on quality of care. The percentage of real-time video consults that would translate into better quality of care is negligible—under 3 percent on any platform.

Is telemedicine cost-effective?

E-mail and internet are cost-effective on all platforms. They would produce per-ship cumulative net savings that range from about $32,650 for carriers to about $2,150 for small ships. Phone and fax are also cost-effective on all platforms. Phone and fax would produce per-ship cumulative net savings that range from about $13,350 for the carriers to about $550 for submarines.

VTC is cost-effective on the carriers and the amphibious ships. On these platforms, the cumulative net savings would amount to about $11,500 and $3,650 for the carriers and amphibious ships, respectively. In small ships and submarines, however, investment in VTC would *not* generate enough monetary benefits (in MEDEVACs and man-days) to justify the expenditure.

Teleradiology is cost-effective on the carriers only. In the amphibious ships, small ships, and submarines, however, teleradiology is *not* cost-effective. Investments in teleradiology for these platforms would not generate the savings necessary to offset the costs.

We based these estimates on the assumption that the ship medical departments will have access to sufficient bandwidth. We estimate that TM's bandwidth requirement would be small—about 1 percent of a month's time.

What if the medical department needs to resort to a commercial satellite? In this case, the transmission costs would add significantly to the cost of the TM equipment. E-mail and internet would be the *only*

TM modality generating enough monetary benefits to offset the overall cost.

What peripheral instruments are cost-effective?

Our findings suggest that on the carriers, the digitized stethoscope, ophthalmoscope, and dermascope are cost-effective. The other add-on instruments do *not* generate enough monetary benefits (in MEDEVACs and man-days) to offset their cost. On the amphibious ships, the stethoscope and ophthalmoscope are cost-effective. On small ships and submarines, none of the peripheral digital instruments would generate enough monetary savings.

Recommendations

Based on our analysis, we make the following recommendations:

For **carriers and amphibious ships**, the Navy should consider:

- Providing medical departments with e-mail and internet, phone and fax, and VTC.
- Providing the carriers with teleradiology.
- Complementing the TM equipment on carriers with a digitized stethoscope, ophthalmoscope, and dermascope.
- Complementing the TM equipment on amphibious ships with a digitized stethoscope and ophthalmoscope.

For **small ships and submarines**, the Navy should consider:

- Providing the medical departments with e-mail and internet, and telephone and fax capabilities.
- Abstaining from investing in VTC and teleradiology. On these platforms, the monetary benefits of these technologies do not cover the costs of implementing them.
- Abstaining from acquiring digitized peripheral instruments. These instruments would not generate enough monetary savings to justify their cost.

If ship medical departments need to rely on commercial satellite, e-mail (the TM modality that consumes the least satellite time) would be the only cost-effective modality. The Navy would realize the greatest benefits from telemedicine by providing ship medical departments with greater access to the ships' communication capabilities.

Introduction

Telemedicine (TM) is an umbrella term that covers various technologies used to transmit information for health services. TM uses electronic information and communication technologies to provide and support health care when distance separates the participants [1].

TM is not a specific technology. It is a means of providing health care from a distance combining telecommunications, computers, and health services. TM spans every echelon of health care, from point of injury to definitive care, including tertiary medical specialty consultations.

Telemedicine makes it possible for physicians and other health care providers to see patients and share diagnostic information in geographically dispersed areas. It uses technology that allows the transfer of medical information between platforms at sea and medical facilities ashore. Performing consultations in this manner increases access to specialized medical resources. It has the potential to avoid some costly medical evacuations (MEDEVACs) and to improve the quality of care for deployed sailors and Marines.

The U.S. Navy's use of TM technology has been demonstrated through various initiatives involving USS *George Washington* (CVN-73) and USS *Enterprise* (CVN-65) in the Atlantic Fleet, and USS *Carl Vinson* (CVN-70) and USS *Abraham Lincoln* (CVN-72) in the Pacific Fleet. The Navy has also used it at McMurdo Station in Antarctica, and naval hospitals at Bethesda, Portsmouth, and San Diego.

In an effort to enhance medical services at sea, the Navy is considering taking TM beyond the demonstration phase by installing the equipment on over 300 ships and Fleet Marine Force units. Because this would be a significant investment, the Surgeon General has asked CNA to determine the cost-effectiveness of the technology.

Issues

Having telemedicine capability aboard ships and at remote locations should save the Navy money mainly by avoiding MEDEVACs and returning sailors to full duty more quickly. We investigated the following issues:

- What is the potential TM workload?
- What are potential savings from TM?
  - MEDEVAC-related
  - Man-days
- What configurations of TM are cost-effective?
- What is TM's bandwidth requirement?

This study compares the *peace time* benefits and costs of the proposed implementation of TM. Because TM is intended to support the Fleet, we focused on operational applications of the technology.

Defining terms

The greatest potential for telemedicine is in medical consulting. We view the consulting process as an interaction between a referring independent duty corpsman or physician (the "consumers" of TM), and specialist-consultants (the "providers"). The providers are physicians on ships or at land-based hospitals.

Medical staffs on different types of ships have varied levels of medical training, experience, and resources. Consequently, the ability to deal with medical problems with onboard resources, and the need for consulting will vary considerably across platforms.

We estimate the demand for TM in the Fleet by ship platform. Differences in the number of onboard personnel, medical staff size and training, space, and communications capabilities suggest the following distinct platforms:

- Aircraft carriers (CV and CVN)
- Amphibious ships (LPH, LPA, LPD, among others)

- "Small" ships (DD, DDG, oiler, minesweeper, among others)
- Submarines (SSN and SSBN).

Scope of study

In addition to considering where to implement TM, we must address how to implement it. We consider four telemedicine modalities. The Fleet could implement the modalities in various combinations depending on demand and cost-effectiveness. The four modalities we consider are:

- **Telephone.** This includes facsimile (fax) capability.
- **E-mail and internet connectivity.** This provides the ability to send and receive e-mail with attachments, such as digitized medical images. Used in conjunction with an external digital camera, it allows for the transmission of pictures and videos in "store and forward" mode. Internet connectivity allows for the posting of pictures and videos on the world wide web and enables searches of medical resource materials on the internet.
- **Video-teleconferencing (VTC).** This provides real-time audio and video connectivity between consumers and providers. VTC has proved particularly useful in psychiatric consults where face-to-face communication is usually necessary.
- **Teleradiology.** This consists of an X-ray machine and a means of producing a digitized image of the X-ray. In its simpler form, teleradiology consists of a film-based X-ray machine and a digitizing film scanner. Computed radiology, a more sophisticated implementation of teleradiology, uses a filmless X-ray machine to produce a digital image directly. Our analysis focuses on the simpler (and less expensive) version of teleradiology.

Digital diagnostic instruments

Telemedicine can be enhanced when used in conjunction with various digitized diagnostic instruments. We consider the following instruments (applications in parentheses):

- Dermascope (skin lesions and anomalies)
- Ophthalmoscope (eye exams)
- Otoscope (internal ear exams)
- Stethoscope (cardiology and other areas)
- Endoscope (surgery)
- EKG and defibrillator (cardiology)
- Ultrasound (radiology).

Administrative automation software

We do not include information management technology in our analysis. This technology automates medical administrative functions. It also improves the tracking of patients and medical supplies, and provides access to CONUS-based digital archives. An example of this technology is the Composite Health Care System (CHCS). One of the capabilities of CHCS is the storage of electronic patient records. Another is the transmission of text e-mail messages—with no attachments—between TM consumers and providers. The e-mail modality of TM we consider in this study allows for the transmission of attachments.

Ship communications capabilities

Communication is the core of any telemedicine application. The telemedicine modalities we looked at have different bandwidth requirements. Bandwidth has two dimensions that are relevant to the processing of TM communications: density (number of bytes per second) and duration (the time it takes to process).

The overall bandwidth requirement is the product of density and duration. For e-mail, the density is usually not a constraint. While a 10-megabyte image of an X-ray can be transmitted over a 9.6-kilobyte per-second (kbps) line, it will take about 7 times longer than with a 64-kbps line.

VTC, on the other hand, requires a minimum density of 64 kbps, and at least 128 kbps for a diagnostic-quality picture. This requirement is

currently a constraint on small platforms because either they do not have the required 64-kbps line or they usually use it at near full capacity for non-medical purposes.

Several ships, such as aircraft carriers, have good telecommunications capabilities. Under the Challenge Athena program, some ships have received a T1 line, with a 1.5-megabyte-per-second capacity. If available to the ship's medical department, a T1 line is sufficient to support any form of telemedicine aboard ship. However, recent experience has shown that, even on ships with Challenge Athena, bandwidth is rationed. The onboard medical department usually has low priority for using bandwidth.

In the absence of the necessary bandwidth, medical departments may have to buy satellite time. International Maritime Satellites (INMARSAT), a commercial satellite system, provides relay of voice and data communication. Many ships currently use INMARSAT for some of their transmissions.

The greatest potential for TM lies in the proposed expansion of ships' telecommunication capabilities under the new Information Technology for the 21st Century (IT-21) plan. IT-21 is a FLTCINC-initiated effort to overhaul information technology in the Navy. IT-21 is expected to provide connections from ships to satellites and shore networks beginning in FY 2000.

IT-21 would provide for local area networks afloat, as well as off-the-shelf personal computers with Windows NT. IT-21 would also extend the satellite communications capabilities to provide each ship with a T1 line. IT-21 should provide ship medical departments with sufficient computing capacity to support the TM equipment we investigated.

Data and methodology

Sources of data

Survey of ship medical departments

Ships do not record MEDEVAC information in a consistent or uniform manner. Mainly for the purpose of reconstructing recent MEDEVACs, we developed a self-administering survey. Fleet Surgeons distributed the survey to ships' medical staff. (Appendix A contains a copy of the survey.)

The survey reconstructs MEDEVACs that occurred during the period 1 September 1995 through 1 September 1996. It collected a variety of information about MEDEVACs, including patient diagnosis, destination, means of transportation, and potential effect of TM in avoiding the MEDEVAC.

Sample selection

We worked with the Fleet Surgeon staff to select a representative sample of ships to complete the survey. The type commanders distributed the survey to the ships.

Table 1 shows the types and number of ships we requested to survey from the Atlantic and Pacific Fleets. We asked Fleet Medical for all aircraft carriers and amphibious ships, and five ships from each of the other ship types. We asked for ships that had deployed for at least 90 days during the period. The overall response rate to the survey was slightly above 50 percent (62 of 120 requested ships).

Shipboard medical encounters

The Fleet Surgeons also asked ships to submit medical encounters data. Most ships use the Snap Automated Medical System (SAMS) to

maintain records of medical encounters. Each ship maintains SAMS on a voluntary basis and does not report it up the chain of command.[1]

Table 1. Ships sampled and responses

Ship type	Number requested per fleet	Deployment criterion	Completed surveys	Submitted SAMS data
Carriers				
CV and CVN	All	None	13	0
Amphibious ships				
LHA and LPH	All	None	5	1
LHD	All	None	2	0
LPD	All	None	6	5
LSD	All	None	6	4
Small ships				
DD, CG, and CGN	5	90 days	5	1
DDG and FFG	5	90 days	6	1
AO and AOE	5	90 days	4	3
AD and AR	1	90 days	0	0
AS	1	90 days	0	0
MCM[a]	5	90 days	2	1
Submarines				
SSN	5	90 days	10	5
SSBN	5	90 days	5	3

a. Atlantic Fleet only.

SAMS is a database application that runs on a personal computer. In addition to documenting medical encounters, SAMS records, among others, physical examinations, shots, visual and hearing exams, radiation health records, occupation health records, and supply management.

1. Our review of the individual medical records suggests that each ship has its own style for recording medical encounters in SAMS. Although some ship medical departments do not record all cases in SAMS, it appears that they all keep track of the more serious cases. The more serious cases are the ones most likely to lead to TM referrals.

The medical encounter information of interest to us included the ICD-9 diagnostic code,[2] patient symptoms and relevant medical history, and prescribed treatment. It also included the number of light duty or no-duty days recommended as a result of illness or injury, and referral for follow-up treatment.

Not all ships maintain data on SAMS. For example, none of the carriers uses this database to record medical encounters. Carriers do not use a standard database for recording medical encounters. Because of this, the response rate for the SAMS data request was not as high as for the survey. Twenty-four ships returned usable SAMS data.

Although SAMS records MEDEVACs, it does not contain information about a ship's location at the time of the MEDEVAC. Also, details about the destination and transportation of the patient are generally lacking. We relied on our survey for MEDEVAC information.[3]

Panel of experts

Because some of the TM technologies are new, few fleet medical personnel have actually used them. Relatively few medical staff are familiar enough with the technology to provide reliable judgments about TM's potential. Therefore, we assembled a panel of medical experts with ample experience with Navy TM to review the SAMS data. All of the panel members were knowledgeable about, and had experience with, TM as either consumers or providers (see table 2).

We asked the panel to verify the applicability of TM to the case-mix reported in the medical encounters data. In particular, we asked the panel to estimate the reduction of patient no-duty and light-duty days

2. Many of the encounters did not include an ICD-9 code. Nonetheless, using the available narrative descriptions, we were able to assign ICD-9 codes to most of them.

3. The reconstructions of MEDEVACs in the survey lacked detail about specific TM modalities that might be used. In many cases, respondents indicated only that they would use some form of TM in the MEDEVAC. For these reasons, we used the SAMS data to extrapolate expected TM modalities used in MEDEVACs. Appendix B contains the factors for crediting MEDEVAC savings to individual TM modalities.

through the application of TM. This allowed us to estimate the personnel productivity savings.

Table 2. Composition and background of panel of experts

	Background or specialty	Rank	Command
Physicians	Fleet Medical Officer	CAPT	SURFPAC
	Professor of Dermatology	CAPT	USUHS
	SMO (CVA)	CDR	USS George Washington
	Former SMO (CVA)	CDR	BUMED
	Director, MIDN Project[a]	CDR	NNMC
	GMO, SW	LT	BUMED
	Internal Medicine	Civilian	NNMC
IDCs	Analyst, MIDN Project	HMC	NNMC
	Corpsman, SW	HMC	BMC Arlex
	Corpsman, SW	HM1	BMC Arlex
	Corpsman, SS	HM1	Washington Navy Yard

a. The Telemedicine Multimedia Integrated Distributed Network uses telemedicine to support remote clinical consultations with ships at sea and the Naval Academy.

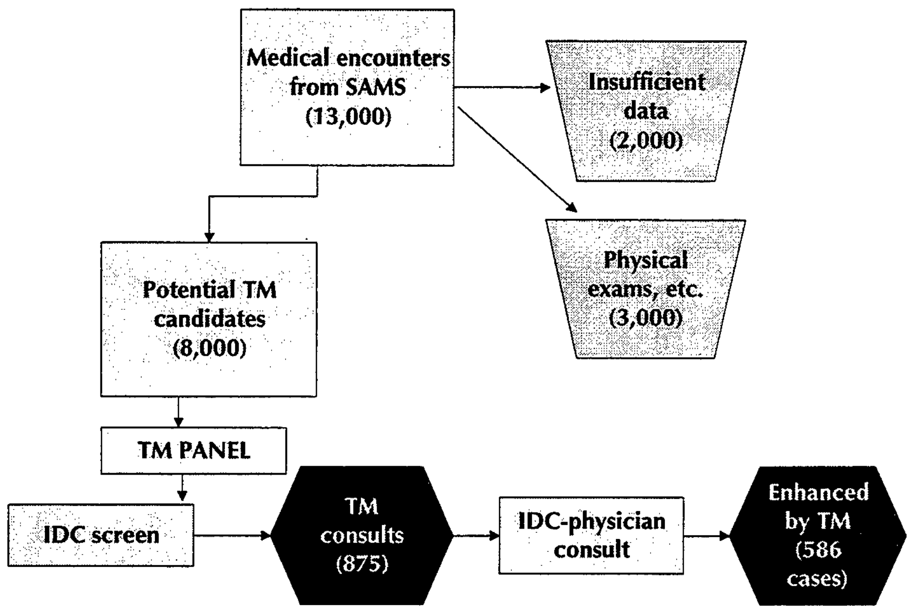
This is how the panel of experts worked (see figure 1). We started with more than 13,000 medical encounters from SAMS.[4] We screened out about 2,000 cases because they had too little detail. We also screened out cases in which TM would have no impact, such as routine physical exams and common colds. This screening eliminated about 3,000 cases.

We then presented the remaining 8,000 cases to a group of Independent Duty Corpsmen (IDCs) with vast operational experience. We asked the IDCs to review and select those cases in which they thought a consult with a specialist would help establish or confirm a diagnosis

4. We observed differences in case mix for ships with similar crew sizes and medical staffs. We also observed that some ships of a given class had more MEDEVACs than others. We believe that this variance is largely due to random factors, such as accidents and bad weather conditions. Some deployments are better than others for the medical departments.

or treatment path. At this stage of the evaluation, the specific modality of TM was not a consideration. That is, the IDCs simply selected cases on the basis of the need for consultation with a physician, independent of how they would do it.

Figure 1. Panel of experts process



To account for differences in medical staff training and available diagnostic equipment on different platforms, we asked the IDCs to pay attention to the type of ship. For example, if the case were orthopedic and came from an LHA, the IDCs were to keep in mind that the ship's medical staff includes several physicians. On the other hand, if the case were from a ship with an IDC only, the likelihood of a consult would be greater.

We developed a printed form showing the available clinical information for each case. Appendix C contains a sample of this form. After reviewing all 8,000 cases, the IDCs selected 875 for a telemedicine consultation.

In the next step, the IDCs presented the 875 cases to Navy physicians—by specialty—to determine the possible role of TM. We asked the full panel to review each case and do the following:

- Estimate the number of light-duty and no-duty days that TM would have saved.
- Determine which TM modalities would have enhanced delivery of care.
- Identify which digitized medical diagnostic instruments the consumer would have needed to send information to the consultant.

Other data

Aircraft flying costs

To complement our MEDEVAC data, we obtained operating costs of aircraft that typically conduct MEDEVACs [2]. These data include the hourly flight cost of the pertinent Navy fixed-wing and helicopter models. From these data, we calculated the MEDEVAC cost attributable to the following:

- Fuel
- Depot-level repairables
- Maintenance.

The fixed-wing aircraft include both carrier-based and land-based. The helicopters include carrier-based, DD-, CG-, FF-based, logistic-ship-based, and land-based. We selected the cost of flight missions likely to include MEDEVACs. Appendix D contains a complete list of the aircraft we used and their corresponding fuel and maintenance costs.

Ship steaming costs

We also obtained data to estimate the cost of diversions and returns to port for ships involved in MEDEVACs [3]. Using these data, we calculated the hourly variable cost of the following ship inputs:

- Petroleum, oil, and lubricants
- Repair parts

- Direct depot maintenance (labor and material)
- Non-scheduled repair (labor and material).

Appendix D contains these costs for ships in the active fleet.

Method of analysis

Which modalities of TM would constitute a cost-savings investment? We use the "net present value" for deciding whether implementation of a TM modality is justifiable on economic principles. The net present value is the discounted monetized value of expected net benefits—that is, benefits minus costs.

We compute the net present value by assigning monetary values—whenever possible—to benefits and costs. We discount future benefits and costs using the appropriate discount rate, and subtract the sum of discounted costs from the sum of discounted benefits.

Why do we need to discount benefits and costs? We discount benefits and costs to transform gains and losses occurring in different time periods to a common unit of measurement. This reflects the time value of money. Benefits and costs are worth more if they are experienced sooner. The higher the discount rate, the lower the present value of future cash flows.[5]

Because future inflation is highly uncertain, we avoid having to make assumptions about the rate of future inflation. We perform all our analyses using constant-dollar values. All the benefits and costs we compute are in 1997 dollars.[6]

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5. The discount rate is $1/(1+r)^t$, where r is the real interest rate on Treasury notes and bonds. The time variable t starts at the number of years from the present to the project's initiation. It ends at the number of years from the present to the project's end. In our analysis, we use 3.3 percent, the February 1997 real interest rate on notes and bonds with five-year maturity [4].

6. We use the appropriate price indices to inflate values priced in previous years to 1997 levels. Because we use constant-dollar values, we adjust the discount rate to eliminate the effect of inflation. Our discount rate strictly reflects the interest rate.

In general, investments in technology with positive net present value are desirable because the benefits outweigh the costs. Investments with negative net present value are generally not desirable.

As in most cost-benefit analyses, the net present value of TM equipment for the fleet is not fully measurable. For some of the benefits of TM, no direct monetary value is available. In these cases, we provide other measures of their effects. For example, we estimate the proportion of consults in which TM equipment would enhance quality of care.

To perform the cost-benefit analysis, we focus on the following:

- *Incremental costs and benefits.* We calculate the net present value based on incremental costs and benefits. We ignore sunk costs, that is, costs that would exist even if TM is not implemented. Likewise, we ignore benefits that would exist even if TM is not implemented. For example, we ignore the fuel and maintenance cost of MEDEVACs conducted on non-dedicated transport such as those on the mail run or logged as training hours.
- *Opportunity cost of resources.* Our estimates reflect the forgone opportunity of resources, such as the lost productivity of a ship's crew that diverts to evacuate a patient. We measure the opportunity cost of the crew by their compensation.
- *Complementary equipment.* We account for the fact that, in some cases, the fleet would generate benefits from a given TM modality only if other equipment is available. Also, for some consults, TM would be beneficial only if other TM modalities are available. For example, teleradiology is used in conjunction with e-mail (or telephone) for transmission of diagnostics readings.

Measuring benefits

We estimate the life-cycle benefits of implementing TM aboard ships. That is, we estimate the benefits for the life of the equipment. As is common in cost-benefit analyses of technology investments, we assume the life cycle to be 5 years. This reflects the equipment depreciation as a result of wear and tear (an important consideration for shipboard equipment), as well as technological advances.

We consider the life cycle to span from FY2000 (the year TM would be implemented) to FY2004. To do this, we assume that the size of the fleet will be in a steady state during the period so that any ship getting TM equipment will have it for the entire 5 years. We also assume that the size and composition of shipboard medical departments will not change considerably during the period.

We now discuss the potential benefits of TM. We can assign a dollar value to some of the benefits. For others, though, a direct measure of the monetary savings is not computable. We base our estimates on the assumption that the equipment will work reasonably well.

Prevented medical evacuations

Fuel and maintenance. We estimate the number of MEDEVACs that TM would prevent. We quantify the fuel, depot-level repairables, and maintenance savings associated with prevented MEDEVACs. We include the cost associated with flying as well as ship diversions and returns to port.

To obtain the net contribution of TM, we focus on MEDEVACs performed on dedicated transport. That is, we focus on MEDEVACs that represent an additional fuel and maintenance cost to the fleet.

In some cases, patients are transferred more than once. For example, an ill sailor on a destroyer is evacuated to the battle group carrier. At a later point, he is transferred to an OCONUS land-based medical facility. The sailor is finally transferred to a CONUS naval hospital for definitive care. For each of the three MEDEVACs, we take into account the type of aircraft used and whether the transport was dedicated.

Patients returning to CONUS for further care usually fly on U.S. Transportation Command planes. USTRANSCOM is financed by an OSD program, with no charge to the individual services. An additional flight to transport a sailor to CONUS, then, represents no direct cost to the Navy. We do not include the cost of these flights in our estimates.

Ship's crew. We estimate the compensation cost of ships diverted for the purpose of evacuating a patient.

Air crew. We also estimate the compensation cost of the air crew that conducts the airlift.

Medical staff travel. Ship medical staff, a junior corpsman in most cases, accompanies the evacuated patient. This arrangement represents lost productivity for the ship medical department. By avoiding some MEDEVACs, TM prevents this productivity loss. We estimate these savings for each prevented MEDEVAC.

Aircraft hazards. Medical evacuations are not only costly, but also potentially dangerous to those involved. We apply the probability of occurrence of a safety hazard to the fixed-wing and helicopter travel TM would avoid. We obtained the hazard probabilities from the Navy Safety Center.

Reduced return-to-duty time

By enhancing their diagnostic ability, TM may, in some cases, help the onboard medical staff return patients to full duty more quickly. This represents savings in productivity. Based on the panel's review of shipboard medical encounters, we estimate the man-day savings that each modality of TM would generate. Appendix E contains a detailed description of the logic we used to assign man-days saved to specific modalities of TM. Our estimates include the potential man-days saved for Marines on board amphibious ships.

Nonmonetary benefits

Other benefits of TM are quantifiable, but do not have a direct monetary value. These include the following:

Enhanced quality of care. The ability to communicate with specialists may, in some cases, help the onboard medical staff establish or change the diagnosis or treatment. This represents better quality of care for sailors. We estimate the number of cases in which TM would enhance the quality of care.

Faster access to higher-level care. In some cases, TM may help the onboard medical staff determine the severity of a patient's condition. We estimate the number of cases in which TM expedites the MEDEVAC. We

also estimate the number of cases in which TM facilitates the decision to conduct a MEDEVAC.

Peripheral medical instruments

To augment the diagnostic capabilities of the four modalities of TM, medical staff could use a variety of digitized add-on instruments. We took into account the cases in which the medical staff would need one or more of these instruments to perform a fruitful telemedicine consult. To assess the net effect of the four TM modalities, we excluded the savings associated with cases in which the instrument would be necessary.

We also conducted a cost-benefit analysis of the peripheral instruments. We applied to the instruments the same methodology we applied to the TM modalities. We computed the net present value of the instruments based on the same types of benefits and costs associated with TM modalities. To do this, we assumed that these add-on instruments are useful only if the basic TM equipment is available.[7]

We estimated the demand for those TM consults that would require a particular diagnostic instrument. In this way, we were able to estimate the marginal benefit of adding a particular instrument to the TM "package."

Measuring costs

We estimated the life-cycle cost of implementing TM aboard ships. We computed the cost of telemedicine equipment using a methodology developed by NMIMC. This methodology inflates the hardware cost to account for the added expenditures on installation, as well as for the necessary training, maintenance, and supplies.[8]

7. The large platforms already have many of the instruments in non-digitized form. On the small platforms, the onboard IDCs may not have the specialized training needed to use the instruments to diagnose and treat patients without the assistance of a specialist. Based on this, we assume that peripheral instruments would not provide benefits if the TM modalities are not available.

8. NMIMC's Theater Medical Information Project developed this methodology [5].

Several large ships have used off-the-shelf VTC and teleradiology units, as well as several peripheral instruments during recent deployments. We adjusted off-the-shelf prices using NMIMC's methodology.

Prices for specific types of equipment vary greatly depending on the specifications (such as resolution and sound quality). We reviewed telemedicine equipment from different vendors. We selected equipment with specifications similar to those already in use in some ships and that were in the lower end of the price range. This accounts for the typical decline in the price of new technology over time. It also accounts for the probability that the Navy would buy the equipment in bulk at a discount.

Based on NMIMC's methodology, in addition to the hardware cost, we calculate the following (percentages of the hardware cost in parentheses):

Up-front costs

- Installation (15 percent). This includes 5 percent for software and 10 percent for general infrastructure investment.
- Connectivity (10 percent). This refers to the connection between naval telecommunication centers and ships. It includes the cost for schematic drawing of shipboard local area network (LAN) connection.
- Training (4 percent). This includes training for system administrators, as well as production of maintenance and operation manuals. NMIMC's methodology assumes that the Office of the Secretary of Defense for Health Affairs, OSD (HA), under the Defense Health Program, would provide funds for medical personnel (end-user) and periodic refresher training.[9]

9. NMIMC's methodology also assumes that OSD (HA) would provide funds for integration and programmatics.

Recurring costs

- Maintenance (2 percent). This includes sparing, replacement, logistics support, and shipping. It also includes customer support services from NAVMASSO and SPAWARS.
- Supplies (5 percent). NAVMEDLOGCOM would manage supplies for distribution to platforms.

The extra cost imposed by these up-front and recurring costs amounts to multiplying the hardware cost by 1.47 (see appendix F).

Shore-based support

Many of the TM consultations would involve an IDC on a small ship or submarine and a physician aboard a large ship. For those that would require the intervention of a land-based medical specialist, we assume that physicians currently working for any of the major naval hospitals would provide TM consultation.

A prototype for this setup is the Telemedicine Multimedia Integrated Distributed Network (MIDN). This network currently supports remote clinical consultations with ships at sea and the Naval Academy. MIDN channels TM consulting, drawing from existing medical resources.

Projecting our sample estimates Navy-wide

To obtain Navy-wide estimates, we project our sample estimates using the appropriate scale factors. For each platform, we derived the Navy-wide estimates by multiplying our sample estimates by these scale factors. We do not include reserve, Military Sealift Command, and some support ships.[10]

Medical evacuations

We focus on MEDEVACs involving aircraft flights, ship diversions, and returns to port. We base our MEDEVAC scale factors on the

10. Our computations exclude the following types of ships: PCs, TAEs, TAFs, TAGSs, TAGs, TAGMs, TAHs, TAKs, TAKRs, TAOs, TAOTs, TAFTs, and TAVBs.

number of deployed months. For each platform, the MEDEVAC scale factor is the ratio of the sum of deployed months of the entire active fleet and the ships in our sample.[11] This method provides a measure of the average number of months spent deployed for the fleet. It accounts for the fact that the ships we surveyed were selected because they had a major deployment during the year.

Man-day savings

Medical encounters take place through the different phases of a ship's employment. Our scale factors are based on the number of commissioned months for each platform. They are the ratio of the sum of commissioned months in the entire fleet and the survey ships during the period.[12]

Some of the ships in our sample did not have medical encounters data for the full 12-month period. In some cases, ships purge (or archive) old data as they upgrade the software. We adjusted our man-day scale factors to take into account the missing data.[13]

We multiply our man-day savings estimates by the scale factor to obtain the Navy-wide estimates. This approach assumes that the ships from which we obtained medical encounters data are representative of their ship class.[14] All of the ships in our sample were in commission for the entire 12-month period.[15]

11. The MEDEVAC scale factors are 1.24, 1.84, 6.31, and 5.78 for carriers, amphibious ships, small ships, and submarines, respectively.

12. The man-days scale factors are 5.64, 26.47, and 19.27 for amphibious ships, small ships, and submarines, respectively.

13. On average, amphibious ships, small ships, and submarines in our sample had 10.6, 11.4, and 8.4 months of complete data, respectively.

14. We observed variations in case mix for ships with similar crew sizes and medical staffs. We also observed that some ships of a given class had more MEDEVACs than others. We believe that random factors account for most of the variance in MEDEVACs and case mix.

15. We added the SSN's average deployed months for each of the 18 blue and gold SSBN crews.

Automated medical encounters data are not available for carriers. Carriers do not maintain records of their medical encounters in the SAMS database. Nonetheless, the nature and composition of medical encounters on the carriers are similar to those in amphibious ships. Carriers, though, have a much larger volume of encounters.

To obtain Navy-wide estimates for the carriers, we inflate the amphibious ships' estimates by a carrier scale factor. This scale factor is the ratio of the total number of billets authorized (an approximation of ship manning) for the carriers and the amphibious ships. Because carriers receive an air wing during deployments, which increases their population significantly, we added a deployment-adjusted air wing crew to the carriers.[16]

Marines' medical encounters are not reported along with those of the ship's company. We based our estimates of the man-day savings of Marines on board amphibious ships on the amphibious ship estimates. The scale factor for Marines is the ratio of the deployment-adjusted Marine Expeditionary Unit (MEU) personnel and the billets authorized for the amphibious ships. We assumed that the typical Marine on board an amphibious ship has the same paygrade as that of the typical sailor.[17] We also assumed that the incidence of illnesses among Marines on amphibious ships is the same as that of the ship's company.

16. The end-of-FY96 number of billets authorized for amphibious ships was 22,862. For the carriers, the number included 36,735 regular crew members, and a notional air wing component of 2,800 personnel. We prorated the air wing based on a carrier average 19.9 percent deployment time during the year. Thus, the carrier scale factor is 1.924 (43,979 over 22,862).

17. Here again we use the end-of-FY96 number of billets authorized for amphibious ships (22,862). For Marines, we based the number on notional 2,100-personnel MEUs. We prorated the MEUs based on the number of months they were deployed during 1 September 1995 to 1 September 1996. Thus, the scale factor for Marines is 0.291 (6,652 over 22,862).

Findings

Potential demand for telemedicine

We estimated the potential demand for telemedicine. If TM equipment were available to the entire fleet, ship medical staffs would initiate over 18,500 TM consults in a one-year period (see table 3). This represents 6.7 percent of all medical encounters.

Table 3. Potential number of telemedicine consults (in one-year period)

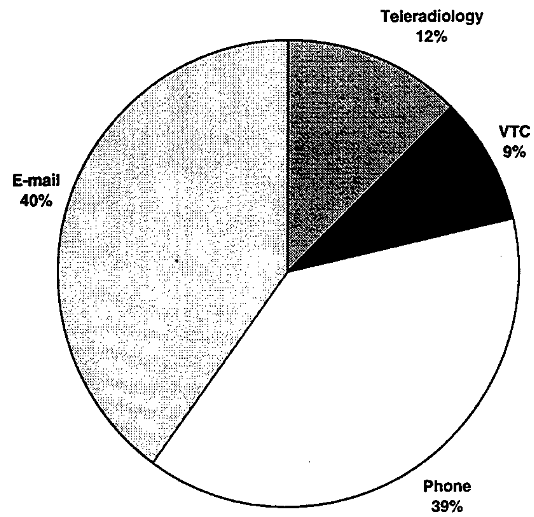
	Number of consults	Percentage of total
Total	18,829	100.0
Quality of care enhanced by TM	12,484	66.3
Digital instrument not required	10,259	54.5
Digital instrument required	2,222	11.8

As we show in figure 2, the majority (79 percent) of these consults would use the less technologically sophisticated TM modalities of e-mail and telephone. Teleradiology and VTC would account for 12 percent and 9 percent of consults, respectively.

We estimate that TM could potentially enhance quality of care for about two-thirds of these consults. Of those, over 80 percent do not require any add-on instrument.[18] For the rest, the consultants felt that a diagnostic instrument would be required. Nonetheless, the lack of such instruments aboard ship would not necessarily reduce the demand for consults.

18. The digital instrument required for a teleradiology consult is a film scanner capable of digitizing a 14 x 17 inch X-ray film. Panel members did not indicate that a computed radiology suite, i.e., filmless, completely digital X-ray, was required.

Figure 2. Distribution of consults by modality



The IDCs identified the medical specialty of the consultant they would request. Table 4 shows the distribution of consults by medical specialty. About 21.4 percent of consults would be with a general medical officer (GMO). This estimate suggests that physicians aboard large ships could probably handle these consults. A telemedicine protocol could, for example, establish that IDCs on small ships should first consult the battle group physician.

Table 4. Potential number of telemedicine consults by medical specialty (twelve-month period)

Specialty	Number of consults
Orthopedics	4,564
General medical officer	4,032
Ophthalmology	1,117
Internal medicine	1,084
Urology	1,076
Gastroenterology	1,070
Dermatology	970

Table 4. Potential number of telemedicine consults by medical specialty (twelve-month period) (continued)

Specialty	Number of consults
Ear, nose, and throat	820
General surgeon	644
Neurology	609
Gynecology	460
Dental	436
Cardiology	434
Psychiatry	403
Pulmonary	190
Preventive medicine	180
Infectious diseases	153
Podiatry	125
Vascular	107
Nephrology	90
Rheumatology	81
Respiratory	72
Radiology	46
Allergy	37
Physical therapy	26
Total	18,829

Orthopedic consults account for the largest group of referrals requiring a specialist (24.2 percent of consults). Ophthalmology accounts for the second largest group of referrals to a specialist (5.9 percent).

Benefits of telemedicine

Medical evacuations

Medical evacuations (MEDEVACs) are transfers of patients from ships for the purpose of providing more definitive medical care. Because they can be particularly costly, we focus on MEDEVACs conducted on aircraft, as well as those involving ship diversions and returns to port.

Armed with the support of medical specialists, the onboard medical staff may be able to diagnose and treat a larger variety of cases. The ability to communicate with specialists quickly may avoid some medical evacuations. In this section, we evaluate the potential benefits of shipboard TM equipment in preventing MEDEVACs.

Based on our survey of ship medical departments, we estimate that Navy ships evacuated 911 patients during the 12-month period of 1 September 1995 to 1 September 1996 (see table 5). Of these, 296 originated in carriers, 395 in amphibious ships, 139 in small ships, and 81 in submarines. Our evacuated patient counts include those of all personnel on board, including embarked Marines. To prevent double counting, we asked ships to report MEDEVACs of their own crew members (and embarked Marines) only.

Large ships perform a significantly greater number of MEDEVACs than small ships. During the 12-month period under consideration, carriers and amphibious ships evacuated an average of 23 and 10 patients, respectively. On the small platforms, the number of evacuations was significantly smaller. Largely reflecting their small crews, small ships and submarines evacuated an average of one patient during the period. The difference in the number of MEDEVACs between the large and small platforms is significant considering that large platforms usually have physicians on their staff.

Table 5. Estimated medical evacuations at sea during 12-month period[a]

	Number of MEDEVACs[b]	
	Total	Per ship[c]
Carriers	296	23
Amphibious ships	395	10
Small ships	139	1
Submarines	81	1
Total	911	

a. 1 September 1995 to 1 September 1996.
b. Includes evacuation of crew members and, for the amphibious ships, embarked Marines.
c. Average based on all Navy ships in each platform.

Where do patients go? The immediate destination of evacuated patients mirrors the presence of Navy ships around the world. In our sample, the most common immediate MEDEVAC destinations were the naval hospitals in Bahrain and Yokosuka, Japan, and the Yokota Air Force hospital in Japan. These were followed by the naval hospital in Sigonella, Italy, and a variety of carriers and amphibious ships.

How do they get there? The most common mode of transportation for evacuating patients to their immediate destination is fixed-wing aircraft (64 percent of cases). Fixed-wing MEDEVACs include those from ships in overseas ports that send patients in an ambulance to the airfield for fixed-wing transport to a hospital. Fixed-wing MEDEVACs are followed by those conducted on helicopter (29 percent of cases), ship diversions (6 percent), and returns to port (1 percent of cases). An airlift is normally necessary to complete MEDEVACs involving ship diversions.

The choice of mode of transportation for conducting MEDEVACs depends on a variety of factors, including the health status of the patient, distance from receiving facility, and capability of aircraft. It also depends on availability of landing area and weather conditions. Because of fuel constraints, helicopters have a range of up to about 100 miles.

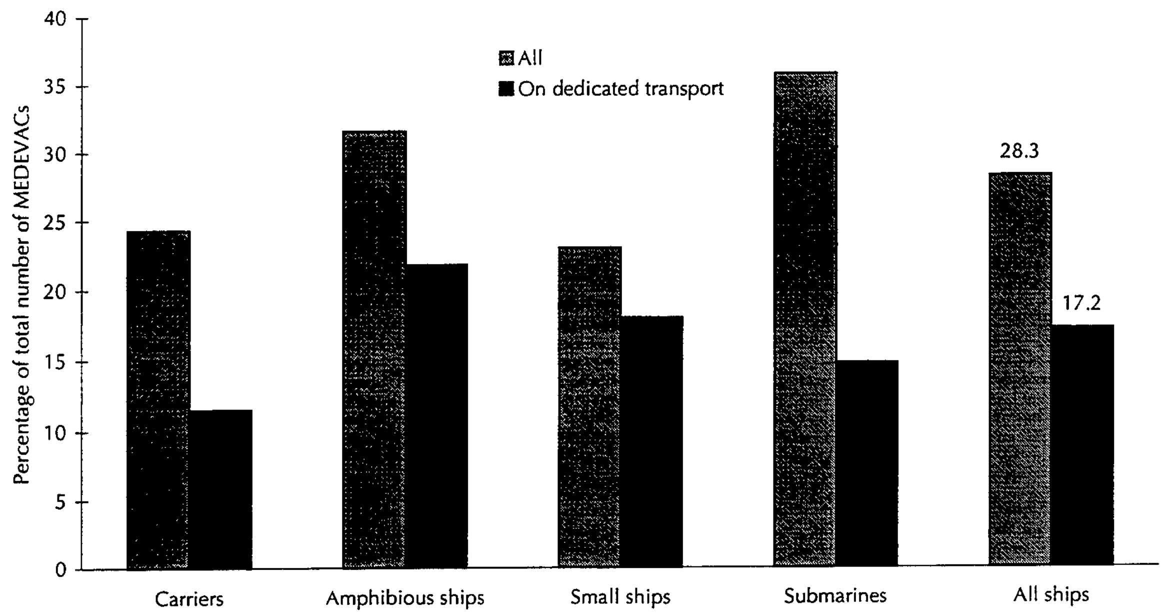
How many MEDEVACs would telemedicine prevent?

We estimated the potential number of MEDEVACs that TM would prevent. We focused on MEDEVACs that, according to the ships' senior medical department representatives, could have been prevented if TM equipment had been available.

According to our survey data, TM would have prevented 28.3 percent of the MEDEVACs during the 12-month period (see figure 3). Interestingly, a 1984 NHRC study [6] reported that onboard medical communications would prevent 28.0 percent of MEDEVACs.

Many MEDEVACs are related to orthopedic injuries (such as broken bones) and psychiatric illnesses (such as attempted suicides). Fleet policy is to evacuate personnel with these conditions. Intervention with TM would not avoid these MEDEVACs.

Figure 3. MEDEVACs telemedicine would avoid (as a percentage of total number of MEDEVACs)



Fuel and maintenance savings

We quantified the fuel, depot-level repairable, and maintenance savings associated with prevented MEDEVACs. We included the steaming cost of ship diversions and returns to port resulting from MEDEVACs.

Do all MEDEVACs represent a fuel and maintenance cost? No. Some patients are put on aircraft whose original reason for flying was other than the MEDEVAC. Other patients are referred to CONUS hospitals on USTRANSCOM airplanes, which do not entail a user's fee to the Navy. Also, patients flying back to CONUS tend to be those in the most acute conditions and for whom TM would have little impact.

To calculate the potential fuel and maintenance savings of TM, we focused on evacuations conducted on *dedicated* transport. We estimate that 17.2 percent of all MEDEVACs during the period would have been prevented by TM and were conducted on dedicated transport.

Based on seven helicopter and three fixed-wing air frames, we calculated the aircraft fuel and maintenance costs of a MEDEVAC (see table 6). The average one-way distance of a helicopter evacuation is 68 miles. Its average hourly cost is $1,149. Thus, the typical helicopter MEDEVAC costs $1,109 in aircraft fuel and maintenance (in FY97 dollars).

Table 6. MEDEVAC-related aircraft fuel and maintenance cost (in FY 1997 dollars)[a]

	Helicopter	Fixed-wing
Average distance (one-way miles)	68	466
Fuel and maintenance cost per hour	$1,149	$1,665
Aircraft fuel and maintenance cost of typical MEDEVAC[b]	$1,109	$4,250

a. Aircraft fuel and maintenance costs were in FY95 values. We used the Producer Price Index to express them in FY97 dollars.

b. This is the cost of a round trip. It is based on average rescue speed of 140 mph for helicopters and 365 mph for fixed-wing aircraft. We weighed the different models' costs with their respective FY96 flight hours.

For fixed-wing aircraft evacuations, the average one-way distance is 466 miles. Their average hourly cost is $1,665. Thus, the typical fixed-wing MEDEVAC costs $4,250 in aircraft fuel and maintenance (in FY97 dollars).

In addition to aircraft, some MEDEVACs involve ship diversions and returns to port. For these MEDEVACs, we added the fuel and maintenance cost of the specific ship type involved. In our sample, the fuel and maintenance MEDEVAC cost of a ship ranged from $2,074 for an LPD to $134 for an ATS (tug boat).

In addition to aircraft and ship fuel and maintenance, TM would produce other savings by avoiding MEDEVACs. These include the pay of crews that divert for the MEDEVAC, the pay of the air crew, and the pay of the ship medical staff that escorts the patient. It also includes the cost of avoided aircraft safety hazards.

Crew

The air crew cost is based on one-day total compensation for a notional crew of one O-5, one O-4, and one E-5. The productivity loss for each MEDEVAC is $789.60, the combined daily compensation in FY97 [7]. This figure includes basic pay, basic allowance for quarters, variable housing allowance, basic allowance for subsistence, prorated share of permanent change of station, and retirement accruals.

To calculate the personnel cost of ship diversions, we used ship-specific manning information from the billets file. The cost is based on one-day compensation (including special pay) for the entire crew by paygrade and rank.

Medical staff travel

Typically, one member of the ship medical staff escorts the evacuated patient. This represents lost productivity for the medical department. By avoiding some MEDEVACs, TM would prevent this productivity loss.

We assumed that an E-5 corpsman accompanies the patient for one day.[19] The productivity loss is $147.26, the E-5 daily compensation in FY97.

MEDEVAC risks

By avoiding some MEDEVACs, TM would reduce the chances of encountering the risks associated with patient transfers. Using our MEDEVAC data, we estimated the potential number of miles that TM would avoid. (We again make the estimates based on MEDEVACs involving dedicated transport.)

We estimate that, if available to the fleet, TM would potentially prevent the following travel miles in a one-year period:

- Fixed-wing aircraft: 147,217
- Helicopter: 8,154

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19. Submarines do not send their corpsman in MEDEVACs. In those cases, a "rescue corpsman" assigned to the aircraft accompanies the patient.

- Returns to port: 592
- Ship diversions: 313.

There are risks involved in MEDEVACs, especially during nighttime and foul weather. We applied the probability of the occurrence of an aircraft safety "hazard" to the fixed-wing and helicopter travel miles above.[20] Examples of aircraft safety hazard are localized aircraft fires, electromagnetic interferences causing loss of a signal, and near mid-air collisions. Hazards cost up to $10,000, and involve no injury or death. We obtained the hazard probabilities from the Navy Safety Center.[21]

We found that over the life cycle of the TM equipment (5 years), TM would help avoid up to eight hazard conditions. The probability of preventing the more serious aircraft "mishaps" (those causing major damage, injury, and death) is low. TM would have no sizable impact on these.

In addition to flying hazards, MEDEVACs involve risks during patient transfers involving ship diversions. This includes the transfer of patients from one ship to another. Submarine MEDEVACs are known to be particularly risky. We did not quantify these risks.

MEDEVAC cost components

Figure 4 shows the cost components of MEDEVACs avoidable by TM. The figures are the average savings in FY97 dollars. On average, the per-MEDEVAC savings amount to about $4,400. The main source of savings is fuel and maintenance ($2,496). This is followed by ship's crew ($979), air crew ($647), ship's medical staff ($241), and avoided safety hazards ($29).

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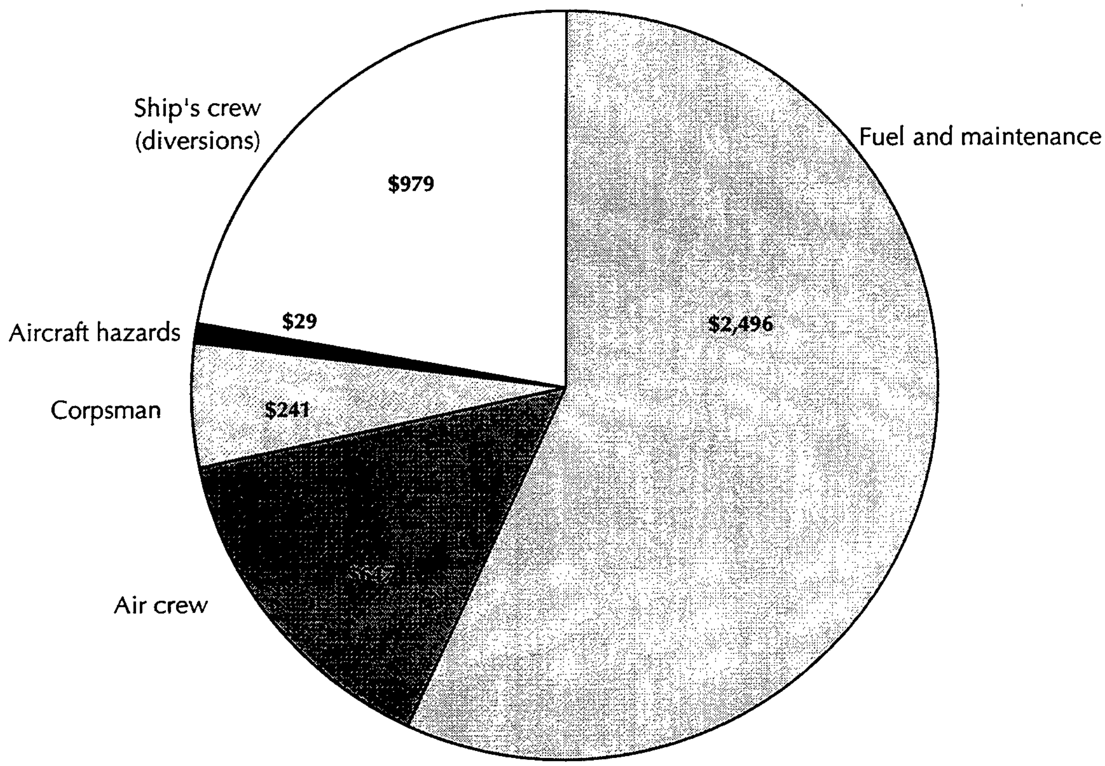
20. We calculated the weighted-average hazard probability for helicopters and fixed-wing aircraft separately. The weights are based on the number of flight hours for each of the three fixed-wing and seven helicopter models during FY 92–FY 97 (through 22 May 1997).

21. The Navy Safety Center hazard probabilities are expressed in flight hours. They exclude bird strikes. We converted flight miles to flight hours using average fixed-wing aircraft and helicopter speed of 365 mph and 140 mph, respectively.

Figure 4. Cost components of MEDEVACs avoidable with telemedicine (average savings in FY97 dollars)



Access to higher-level care

MEDEVACs often result because the onboard medical staff is unable to make a diagnosis. TM would allow experts to review the case at a distance and establish or confirm the diagnosis. TM would help determine the seriousness of the case and the need for further tests or treatment. Thus, TM has the potential for getting patients higher-level care more quickly.

TM would facilitate more than a third of MEDEVACs on all platforms (see table 7). The percentage of MEDEVACs that TM would facilitate ranges from 57.1 percent on submarines to 36.7 percent on amphibious ships.

Arranging for MEDEVACs requires planning and coordination between a ship's medical staff and the receiving facility. This is a time-consuming process. TM would expedite a significant number of MEDEVACs; the proportion ranges from 35.7 percent on submarines to 9.1 percent on small ships. On carriers, TM would expedite 19.9 percent of MEDEVACs. On amphibious ships, TM would expedite 14.0 percent of MEDEVACs.

Table 7. MEDEVACs telemedicine would expedite and facilitate (by platform)

Platform	Facilitate decision (percent of total)	Expedite (percent of total)
Carriers	38.1	19.9
Amphibious ships	36.7	14.0
Small ships	50.0	9.1
Submarines	57.1	35.7

Telemedicine would expedite MEDEVACs by enabling a prompt exchange of medical information. This allows for routing the patient to the appropriate source of care and forwarding data to the receiving facility.

Return-to-duty time

By enhancing their diagnostic ability, TM may also, in some cases, help the onboard medical staff return patients to full duty more quickly. This represents savings in productivity. Based on the medical panel's review of shipboard medical encounters, we estimated the man-day savings that each modality of TM would generate. We distinguished between sailors on limited duty and those on light duty. To estimate overall man-day savings, we assumed that sailors on light duty are half as productive as those on full duty.[22]

22. Sailors on light duty are usually assigned to replace others (for example, doing office work). The sailor on light duty may have little experience in the temporary job. Also, the displaced sailor may, in turn, get assigned to another job, where he may not be as productive. We assume that sailors on light duty are half as productive as those on full duty to capture this loss of productivity.

We estimate that if fully available to the fleet, telemedicine would save 0.42 man-day per consult. We calculate the dollar value of this productivity loss based on the FY 1997 daily compensation for E-5s ($147.26). Table 8 points out the following:

- On the **large platforms** (carriers and amphibious ships):
  - — All modalities of TM would generate significant man-day savings on carriers and amphibious ships. The savings would be significantly greater (at least four times greater) on carriers.
  - — Of the four TM modalities, teleradiology would save the most man-days. The per-ship man-day savings would be about $32,700 and $7,050 for carriers and amphibious ships, respectively.
- On the **small platforms** (small ships and submarines):
  - — E-mail and internet would produce the most man-day savings (about $1,850 and $1,050 per small ship and submarine, respectively).
  - — VTC would generate very modest man-day savings (less than $150 per ship, on average).
  - — Here again, teleradiology would produce no savings on submarines, and very modest savings on small ships.

Incapacitated sailors on small ships represent a much greater productivity loss (relative to the crew size). Also, incapacitated sailors on small ships may be the only crew members with a critical set of skills.

Table 8. Telemedicine per-ship man-day savings (five-year period, in FY 1997 dollars)

	E-mail and internet	Phone and fax	VTC	Teleradiology
Carriers	16,623	6,596	8,180	32,718
Amphibious ships[a]	3,592	1,425	1,767	7,069
Small ships	1,863	488	89	931[b]
Submarines	1,031	147	147	0

a. Includes deployed Marines, which constitute 22.5 percent of the man-day savings.
b. This is a notional savings figure under the assumption that an X-ray is available.

Quality of care

The panel of experts identified cases in which TM consults would enhance the quality of care. Improved quality of care can result because TM helps establish or change the diagnosis or the course of treatment. Table 9 shows the percentage of consults that each TM modality would enhance.

Table 9. Consults in which telemedicine would enhance quality of care (percentages)[a]

	E-mail and internet	Phone and fax	VTC	Teleradiology
Amphibious/carriers	32.5	19.2	2.3	26.9
Small ships	22.2	23.9	1.9	18.3
Submarines	14.3	11.9	1.2	2.4
Total	26.5	20.4	2.1	21.0

a. Consults requiring no add-on instruments only. Medical encounters data were not available for aircraft carriers.

E-mail and internet would have a significant favorable impact on quality of care on the three platforms. The percentage of e-mail and internet consults that would result in improved quality of care for sailors ranges from 32.5 percent for amphibious ships to 14.3 percent for submarines.

VTC, on the other hand, would have very little impact on quality of care. The percentage of VTC consults that would translate into better quality of care is very small—under 3 percent on any platform.

Continuing medical education

Telemedicine could be beneficial in expanding medical distance learning. Onboard medical staff would be able to download instructional and reference materials over the internet. With videoteleconferencing, they would be able to watch, for example, an operation being performed by a surgeon on another ship or a land-based hospital. They would be able to record the operation for

detailed examination. Also, telemedicine would give IDCs the chance to enhance their skills and expand their professional knowledge by linking them to highly skilled clinicians.

Telemedicine could help avoid transportation costs to training facilities ashore. It could prevent time away from duty stations and the associated TAD cost.[23]

Health promotion

Telemedicine could also be beneficial for health care promotion. TM could ease the isolation of deployed medical staff from the rest of the medical community. For example, land-based specialists could be able to track a rise in the incidence of a disease aboard a ship. E-mail could help disseminate preventive care literature to deployed ships.

Costs of telemedicine

Equipment

Telemedicine hardware prices vary widely depending on the specifications. This is especially the case for VTC, teleradiology, and the peripheral instruments that can have, among other things, different image resolution or sound quality.

We observed a wide range of prices for all of these instruments (see appendix G). It was beyond the scope of this study to determine how well each of these instruments would perform as part of a TM suite. In determining the cost-effectiveness, we present the dollar savings associated with using an instrument with adequate performance. We show the prices of the instruments for reference, not as an endorsement of their performance.

Table 10 contains the hardware cost we used in our analysis. We inflated these hardware costs to account for installation, maintenance, supplies, and training.

23. An analysis of the potential training travel costs that TM might avoid is beyond the scope of this study.

Table 10. Hardware cost of TM equipment used in analysis

	Cost ($)
TM modalities	
E-mail and internet	0[a]
Phone and fax	425
VTC	4,000
Teleradiology[b]	16,000
Peripheral instruments	
Dermascope	1,200
Endoscope	4,000
Ophthalmoscope	2,450
Otoscope	2,700
Stethoscope	1,390
Ultrasound	2,000
EKG/Defibrillator	4,500

a. Based on assumption that hardware and software for Internet connectivity would be a part of the ship medical staff's computing capacity.
b. Scanner for film-based X rays. Submarines and most small ships do not have an X ray. This cost does not include the required X ray for small ships and submarines.

Satellite transmission

Ships' bandwidth is currently limited, and may continue to be so in the years ahead. In the absence of the necessary bandwidth, medical departments may have to buy satellite time. International Maritime Satellites (INMARSAT), a commercial satellite system, provides relay of voice and data communication. Several ships are currently using INMARSAT for some of their medical transmissions.

Based on discussions with the panel of experts, medical staff needs an average of 30 minutes to conduct VTC and telephone consults. The satellite time they would need for the other TM modalities depends on the amount of data transmitted. We base message size and its associated transmission duration on the recent experience of ships with TM capability.

We obtained the per-minute rates directly from INMARSAT. Table 11 provides our estimates of the INMARSAT costs per consult. As of June 1997, the cost per minute for voice (9.6 kbps) was $4. For data (64 kbps), it was $10. At these rates, INMARSAT cost per consult would range from $300 for a VTC transmission to only $2 for a text e-mail message.

Table 11. Cost of telemedicine consults using INMARSAT (as of June 1997)[a]

	Duration of connection (minutes)	Cost per consult ($)
E-mail		
No attachment[b]	0.2	2
Attachment[c]	1.6	20
Telephone	30.0	120
VTC	30.0	300
Teleradiology (X-ray)[d]	19.5	200

a. Based on $4.00 for voice (9.6 kbps) and $10.00 for data (64 kbps) transmissions.
b. For a file size of 2,000 bytes.
c. For a file size of 100,000 bytes.
d. For a file size of 10,000,000 bytes.

Is telemedicine cost-effective?

For each modality of TM, we calculated the net present value—the discounted benefits minus the discounted costs—for every ship platform. We consider the following two scenarios:

1. *Ships' medical departments will have access to enough bandwidth.* In this scenario, the Information Technology for the 21st Century (IT-21) plan would provide all the computing capacity ship medical departments need.

2. *Ships' medical departments will not have sufficient bandwidth.* In this scenario, the medical departments would need to use a commercial satellite (such as INMARSAT) for all their transmissions. In this case, the commercial satellite fees would go on top of the telemedicine equipment cost.

Using the ship's satellite connection

Table 12 presents the net present value of TM when the medical department piggybacks on the ship's satellite connection under IT-21. The use of this resource by the medical department would not represent an additional communications cost to the fleet.

Table 12. Per-ship net present value of TM when using ship's satellite connection (five-year period, in FY 1997 dollars)[a]

	E-mail and internet	Phone and fax	VTC	Teleradiology
Carriers	32,674	13,365	11,478	19,541
Amphibious ships[b]	17,208	7,151	3,674	(7,674)
Small ships	2,130	556	(5,629)	(22,141)
Submarines	6,152	2,598	(4,447)	n/a

a. Net present value reflects the dollar value of man-days and MEDEVACs saved minus the cost of the hardware.
b. Includes deployed Marines.

E-mail and internet

E-mail and internet are cost-effective on *all* platforms. The per-ship five-year net savings range from about $32,650 for carriers to about $2,150 for small ships.

Telephone and fax

Phone and fax are also cost-effective on *all* platforms. The per-ship cumulative net savings would range from about $13,350 for the carriers to about $550 for submarines.

Video teleconferencing

VTC is cost-effective on the carriers and the amphibious ships. On these platforms, the five-year net savings would amount to about $11,500 and $3,650 for the carriers and amphibious ships, respectively.

In small ships and submarines, however, investment in VTC would *not* generate enough monetary benefits (in MEDEVACs and man-days) to justify the expenditure.

Teleradiology

Teleradiology is cost-effective on the carriers only. The per-ship cumulative net savings would amount to about $19,550 for carriers.[24]

In the amphibious ships, small ships, and submarines, however, teleradiology is *not* cost-effective. Investments in teleradiology for these platforms would not generate the savings necessary to offset the costs.

Relying on a commercial satellite

What if the medical department needs to resort to a commercial satellite? This would be the case if the medical department does not have access to sufficient bandwidth. Table 13 presents the net present value of TM when the medical department uses INMARSAT for all of its voice, data, and image transmissions.

Table 13. Per-ship net present value of TM when using commercial satellite (five-year period, in FY 1997 dollars)

	E-mail and internet	Phone and fax	VTC	Teleradiology
Carriers	21,774	(44,308)	(5,616)	(72,122)
Amphibious ships[a]	14,853	(5,310)	(19)	(27,478)
Small ships	729	(7,574)	(7,732)	(35,691)
Submarines	5,552	(1,146)	(5,526)	n/a

a. Includes deployed Marines.

In this case, the transmission costs would add significantly to the cost of the TM equipment. E-mail and internet would be the *only* TM modality generating enough monetary benefits to offset the overall cost. E-mail and internet would yield cumulative net savings ranging

24. Our estimates indicate that teleradiology would be cost effective on carriers up to an equipment cost of $29,000.

from about $21,750 for a carrier to about $750 for a small ship. The other TM modalities would not produce enough savings (in MEDEVACs and man-days) to justify the costs.

Figures 5 through 8 summarize our cost-benefit analysis of the four TM modalities. They show the per-ship benefits and costs for each modality.

Figure 5. Per-ship benefits and costs: E-mail and Internet (discounted, in FY97 dollars)

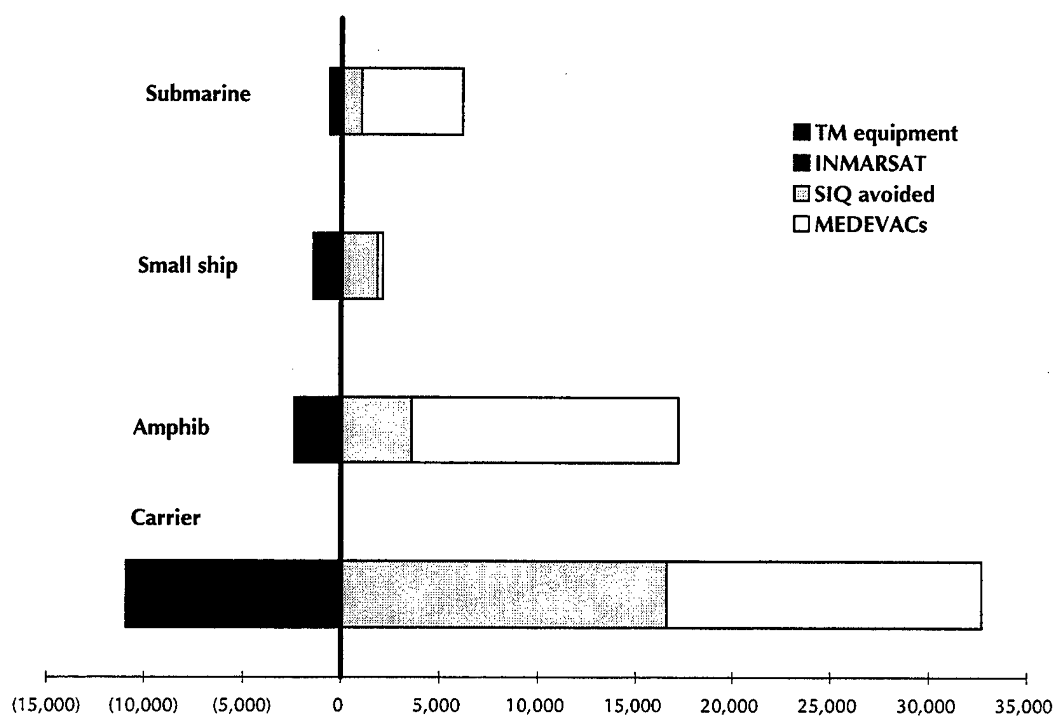


Figure 6. Per-ship benefits and costs: Telephone and fax (discounted, in FY97 dollars)

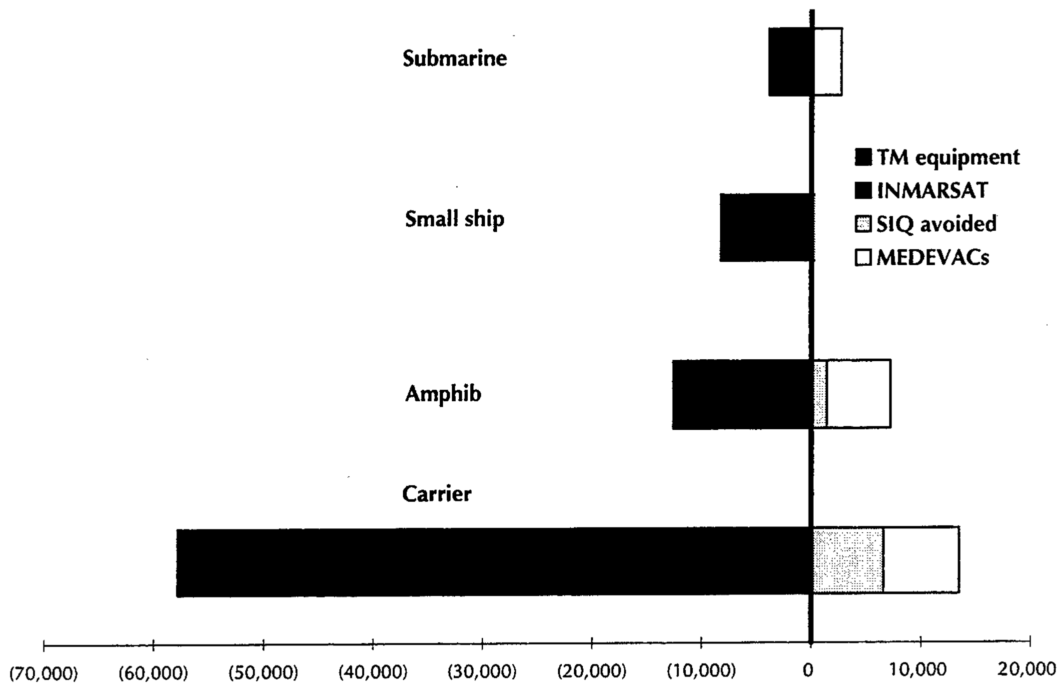


Figure 7. Per-ship benefits and costs: VTC (discounted, in FY97 dollars)

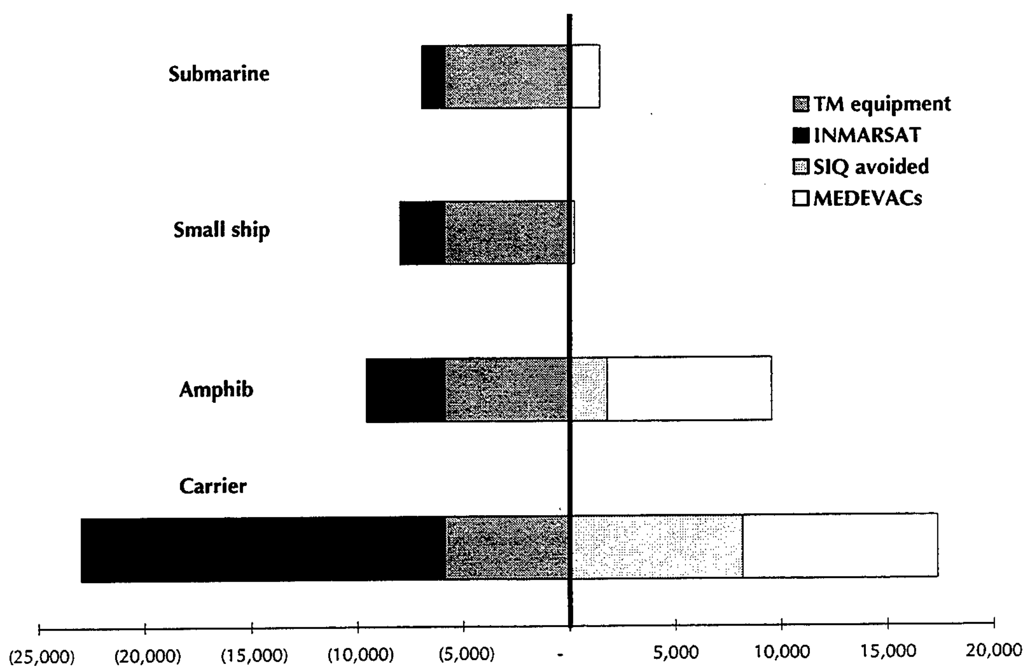
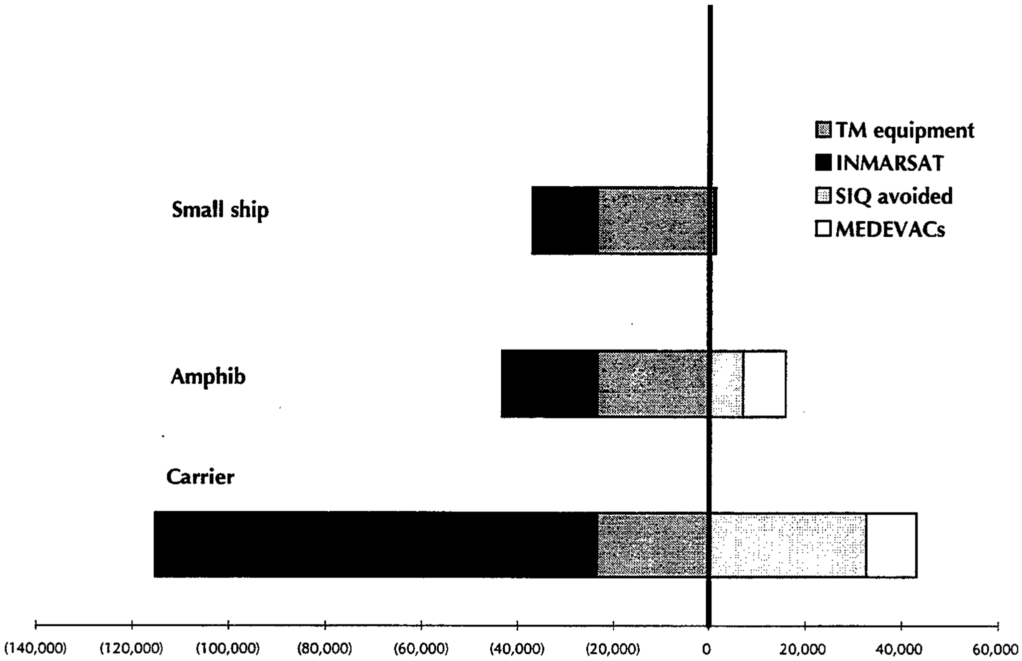


Figure 8. Per-ship benefits and costs: Teleradiology (discounted, in FY97 dollars)



Peripheral medical instruments

To augment the diagnostic capabilities of TM equipment, medical staff could use a variety of digitized peripheral instruments. For some consults, TM would be beneficial only if these add-on instruments are available.

To determine the cost-effectiveness of the peripheral instruments, we calculated their net present value (see table 14). We used a methodology similar to the one we applied to the modalities of TM. That allowed us to determine the benefits of a telemedicine "package" that includes the TM modalities and the respective add-on instruments.

Table 14. Per-ship net present value of peripheral instruments (five-year period, in FY97 dollars)

	Stetho-scope	Ophthal-moscope	Derma-scope	Endo-scope	Oto-scope	Ultrasound	EKG
Carriers	6,788	5,621	2,513	(5,874)	(3,965)	(1,300)	(2,987)
Amphibious ships[a]	2,317	232	(226)	(5,874)	(3,965)	(1,971)	(4,601)
Small ships	(1,309)	(2,938)	(1,021)	(5,635)	(3,305)	(2,758)	(6,478)
Submarines	(2,041)	(2,281)	(732)	(5,874)	(2,648)	(2,937)	(6,608)

a. Includes deployed Marines.

Our findings suggest the following:

- **Carriers**. On the carriers, the digitized stethoscope, ophthalmoscope, and dermascope are cost-effective. Their respective per-ship cumulative savings are about $6,800, $5,600, and $2,500. The other add-on instruments do *not* generate enough monetary benefits (in MEDEVACs and man-days) to offset their cost.
- **Amphibious ships**. On the amphibious ships, the stethoscope and the ophthalmoscope are the *only* cost-effective add-on instrument. They would generate savings of about $2,300 and $250 per ship, respectively. The rest of the instruments do not generate enough monetary benefits to offset the costs.
- **Small ships and submarines**. On small ships and submarines, *none* of the peripheral instruments would produce enough monetary savings.

Bandwidth requirements

Our findings indicate that three of the four modalities of TM we consider—phone and fax, VTC, and teleradiology—would not be cost-effective on any platform if the medical department has to use commercial communications. Would providing the medical departments access to the ship's communications capabilities place a heavy burden on the available bandwidth?

Table 15 shows our estimates of TM's monthly average bandwidth requirements. We distinguish between asynchronous and synchronous modes of communication. Digitized x-rays for teleradiology consults

and e-mail would be transmitted asynchronously in store-and-forward mode using a 64kbps "pipe." Although a narrower bandwidth would suffice for the textual e-mail component, the 64kbps pipe is necessary for transmitting the 10MB x-ray images. Current standards for transmitting x-ray images require error-free transmission. Transmission black-outs would require that the entire image be re-transmitted. Narrower bandwidths for these images would increase the transmission time to a point where an error-free transmission would be difficult to achieve.

Table 15. Telemedicine's per-ship monthly bandwidth requirement (minutes on 64-kbps line)

	Asynchronous	Synchronous	
	Store-and-forward[a] (64kbps)	VTC (128kbps)	Phone/Fax (9.6kbps)
Carriers	167	160	191
Amphibious ships	36	35	42
Small ships	1	0	50
Submarines	1	0	20

a. Includes transmission of X-ray images and e-mail. For simplicity, we assumed that one-half of the e-mail messages contain 100,000-byte attachments.

Synchronous transmission estimates include telephone on all platforms and VTC on carriers and amphibious ships. The high bandwidth requirements of 128kbps for VTC is necessary for producing medical-diagnostic quality full-motion video. Note that INMARSAT does not currently support 128kbps communications. Therefore, the use of VTC is contingent upon access to ships' communications, which should support the VTC bandwidth requirement under IT-21.

In a typical month, store-and-forward communications would use from 167 minutes (2.8 hours) on carriers, to about one minute on submarines. Synchronous, real-time requirements would also vary by platform. Carriers would be the greatest consumers with 191 minutes (3.2 hours) of telephone and 160 minutes (2.7 hours) of VTC connect time. Submarines would use about 20 minutes for consulting by telephone and fax.

What percentage of a ship's communication capacity, under IT-21, does telemedicine's bandwidth requirement represent? If we were to convert the estimates shown in table 15 to a common metric of 64 kbps, for carriers this would equate to 517 minutes—about 1 percent of the 720 hours in a month. Since a 64kbps pipe width represents about 4 percent of an IT-21 ship's total capacity of 1.5mbps, telemedicine's requirements would be negligible on any platform.

Recommendations

We have determined the cost-effectiveness of the four modalities of TM and the add-on instruments based on their monetary benefits and costs. Some of the potential benefits of TM do not have a monetary value. Nonetheless, some of this technology would improve quality of life by improving the quality of care provided on Navy ships. It would also prevent the mission disruptions that some of the medical evacuations create. With this in mind, we make the following recommendations:

For **carriers and amphibious ships**, the Navy should consider:

- Providing the medical departments with e-mail and internet, phone and fax, and VTC.
- Providing the carriers with teleradiology.
- Complementing the TM equipment on carriers with a digitized stethoscope, ophthalmoscope, and dermascope.
- Complementing the TM equipment on amphibious ships with a digitized stethoscope and ophthalmoscope.

For **small ships and submarines**, the Navy should consider:

- Providing the medical departments with e-mail and internet, and telephone and fax capabilities.
- Abstaining from investing in VTC and teleradiology. On these platforms, the monetary benefits of these technologies do not cover the costs.

- Abstaining from acquiring digitized peripheral instruments. These instruments would not generate enough monetary savings to justify their cost.

Although real-time VTC does not generate enough monetary savings to offset its cost on small ships and submarines, these platforms could use internet access to transmit videos in store-and-forward mode.

We base these recommendations on the assumption that ship medical departments would have enough bandwidth under IT-21. If they need to rely on commercial satellite (such as INMARSAT), the cost of telemedicine would increase sharply. In this case, e-mail, the TM modality that consumes the least satellite time, would be the only cost-effective modality at current INMARSAT rates. The Navy would realize the greatest benefits from telemedicine by providing ship medical departments with greater access to the ships' communication capabilities.

Appendix A: Survey of ship medical departments

This appendix contains a copy of our survey of the ship medical departments. Sixty-two of the 120 sampled ships returned the survey.

CNA

CENTER FOR NAVAL ANALYSES

4401 Ford Avenue • Alexandria, Virginia 22302-1498 • (703) 824-2000 • (703) 824-2949 FAX

30 October 1996

Dear military health care provider:

As you may know, telemedicine (TM) equipment is already operational on four aircraft carriers. This capability includes video teleconferencing integrated into a high-speed satellite communications system. This allows for real-time full-motion video and audio consults with specialists ashore and on other TM-equipped platforms. The large deck platforms and hospitals ashore have integrated digital medical instrumentation, such as computed radiology. Using lower bandwidth, TM is also used to store and forward digitized images and text over the Internet, and to do MEDLINE research.

The Surgeon General has asked the Center for Naval Analyses (CNA), a federally funded research and development center, to identify the benefits of providing the medical departments of afloat operational units with TM capability.

To help the Navy make better decisions on how to implement TM in the fleet we are asking you to complete a survey about the potential use of TM. We are also asking you to extract some data from SAMS .

The survey should be completed by the Senior Medical Department Representative (SMDR) aboard your ship. The survey consists of four parts:

1. Background information about your ship's crew and medical staff, as well as your experience using TM technology
2. Possible TM applications to enhance your capabilities
3. A technology wish-list
4. MEDEVACS (personnel transfers for medical care).

The second part of this data collection is an extract of your SAMS data onto a 3½" diskette. (From the *Main* menu of SAMS, select *Utilities*, then *Backup*.) Please place a label on the disk identifying your ship.

We will use this information to determine what TM implementation would be most appropriate for a medical department on a ship like your own. When you have completed the survey and the SAMS extract, please return them both as instructed by your TYCOM.

Your inputs are important! Your time and effort to complete this survey are greatly appreciated.

Dr. Peter Stoloff
CNA Study Director

Telemedicine Survey

The purpose of this survey is to assess the potential use of telemedicine in the fleet. Telemedicine (TM) is the application of information management to health care delivery. It allows for the processing of medical data aboard ship and the transmission of data to specialists on other ships and at medical facilities ashore. Examples of TM include:

- Video teleconferencing (VTC) for face-to-face consultations in real time. Various medical diagnostic instruments, as shown below, can be interfaced with the VTC equipment for use in the consultation. VTC can also provide training opportunities for the medical community at sea.
- The Internet and e-mail for storage and forwarding of digitized information. Transfer of medical records and digitized x-rays, requests for medical information, and searches of medical libraries, such as MEDLINE, are part of this capability. Shipboard CHCS can also be used to send and receive text-only messages between ships and medical facilities ashore, as well as to maintain medical department data in computerized form.
- Telephone/FAX for real-time voice communications and image transmission.
- Computed radiology. Radiographic images are digitized and stored directly in computer files. This eliminates the use of film and chemicals and allows for computer enhancement of images.

The chart below shows the kinds of medical equipment that can be interfaced with a TM system within the limitations of your ship.

Instrument	Application
Dermascope	Skin lesions/anomalies
Endoscope	Surgery
Ophthalmoscope	Eye exams
Otoscope	Internal ear exams
Stethoscope	Cardiology and other areas
Ultrasound	Radiology
X-ray digitizer	Radiology

TM capability can be "packaged" in several ways. Because of communication, staffing, and space requirements, computed radiology and much of the instrumentation shown in the chart will likely be limited to large deck platforms.

Section 1. Background information

About your ship:

Name of ship/duty station: ____________________ UIC __________

Number of people on ship ________ Number of women on ship ____

Percentage of time at sea from 9/1/95 through 9/1/96 _____

Today's date ________ (mm/dd/yy)

Medical department staffing

 # Officers: ____________________ **# Enlisted:** ____________________

MC-GMO ___ MSC-Admin. ___ IDC ___ HM____ DT ___ Other____

MC-Specialist ___ MSC-Allied Health Sci. __

NC ___ DC ___

Medical department SMDR's level of training and experience:

Years of formal medical training (including Navy schools): ____

Years of medical experience since training: ____

Paygrade of SMDR: O- ___ E- ___ Primary NEC (if enlisted) _____

Number of years in operational tours ____

Your staff's background in telemedicine

Please indicate the highest level of familiarity and experience of your staff with the technologies shown below.

Technology	Familiarity (1= very; 2= somewhat, 3= not at all)	Experience (1= very; 2= somewhat, 3= not at all)
Computed radiology		
Video teleconsultation		
e-mail		
CHCS		
MEDLINE		
Internet "surfing"		
Digitized images from the following equipment:		
Defibrillator		
Dermascope		
EKG		
Endoscope		
Ophthalmoscope		
Otoscope		
Stethoscope		
Ultrasound		
X-ray digitizer		
Other		

Section 2. Telemedicine applications

Shown on the next page are areas, grouped by ICD-9 codes, where TM might be used **at sea.** (Feel free to add any areas you feel are appropriate.) Please estimate the following:

- Number of visits for each medical condition that occurred during the period 9/1/95 through 9/1/96, *even if the patient was not a member of the crew*
- Percentage of cases where an intervention by TM could possibly have enhanced the delivery of care to the patient
- Average number of man-days saved *per patient* had TM been available.

We ask you to make these estimates for four TM capabilities.

1. **e-mail and Internet connectivity** (For storing and forwarding of digitized images and text and for accessing on-line medical libraries. You could use this capability to request a consult and receive an e-mail/Internet message reply within 24 hours.)
2. **Telephone/FAX** (Real-time voice communication and image transmission.)
3. **Video teleconferencing** (Real-time, full-motion, two-way audio and video allowing you and/or the patient to see and speak with a medical consultant.)
4. **Teleradiology** (Images are digitized and enhanced, then stored as computer files which can be electronically forwarded for consult. Eliminates film and chemicals.)

Under "# visits," include a visit in as many medical area categories as necessary. If you think it would be helpful, you may want to refer to SAMS (sick call log) for visit information.

*Please limit your responses to patients treated on your **own ship**.*

Medical area			TM capability (within limitations of ship)							
			1. e-mail/ Internet		2. Telephone/FAX		3. Video Teleconferencing		4. Teleradiology	
Category	ICD-9 codes	# visits	% visits enhanced by TM[1]	Man-days saved[2]	% visits enhanced by TM[1]	Man-days saved[2]	% visits enhanced by TM[1]	Man-days saved[2]	% visits enhanced by TM[1]	Man-days saved[2]
Infectious/parasitic diseases	001-139									
Neoplasms (excluding benign of skin)	140-239 (x216)									
Endocrinology/metabolic	240-259, 270-279									
Nutritional deficiencies	260-269									
Hematology	280-289									
Psychiatry	290-319									
Neurology	320-359									
Ophthalmology	360-379									
ENT	380-389									
Cardiac	390-429									
Vascular	430-459									
Respiratory	460-519									
Gastroenerology	520-579									
Urology	580-608									
OB/GYN	610-648									
Dermatology (include benign skin neopl.)	680-709, 216									
Orthopedics (include fractures, disloc., sprains)	710-739, 800-848									
Congenital	740-759									
Ill defined	780-799									
Trauma (exclude. fractures, disloc., sprains)	850-995									
Dentistry	--									

[1] Percentage of cases where an intervention by TM could **possibly** have enhanced the delivery of care to the patient.

[2] Average number of man-days **potentially** saved ***per patient*** had TM been available.

Estimated frequency of use of TM

How many **times per month** would you access and utilize each of the following TM technologies during normal operations, and during a heightened defense posture? (*Assume that you had the instruments listed and they could produce a digitized image which you could transmit to a consultant.*)

TM technology	**Number of times per month**	
	Normal operations	**Heightened defense posture**
Defibrillator/EKG		
e-mail/internet		
Telephone/FAX		
VTC		
Dermascope		
Endoscope		
Ophthalmoscope		
Otoscope		
Stethoscope		
Ultrasound		
x-ray		

Please indicate **other ways** you might use TM to enhance medical care delivery aboard your ship, and its potential effect on the quality of life of the crew.

This section is only for ships with radiology equipment.

Please indicate the workload of your radiology department, as it applies to the medical areas shown. Feel free to add other medical areas where you use radiology.

Medical area	# x-rays	# retakes	# sonograms
Chest examination			
Gastroenterology			
OB/GYN			
Orthopedics			
Renal/Urology examination			
Trauma			

Section 3. Technology wish-list

Please indicate those technologies you would like to have that would enhance your ability to provide medical care. For each technology you list, please estimate the average number of hours per week the use of this technology would save for *all personnel aboard your ship.* List these technologies by the order of their importance. (Do not limit your choice of technologies to those related to telemedicine.)

Order of importance	Technology	Potential *average hours/week* saved	
		Medical dept.	Crew
1			
2			
3			
4			
5			

Section 4. MEDEVACS (personnel transfers for medical care)

Please complete the form below for each MEDEVAC of own-ship's personnel, including any embarked Marines, during the period 1 September 1995 through 1 September 1996. Do not include MEDEVACs of personnel coming from other ships.

MEDEVAC: # ________

Patient SSN[1]: ________ - _____ - ________

Date of MEDEVAC (mm/dd/yy): ____ /____ /_____

Reason (diagnosis/ICD-9) ____________________

Did ship have to divert for MEDEVAC? No ☐ Yes ☐ *If yes*, how many days:_____; nautical miles: __________

Did another ship assist with MEDEVAC? No ☐ Yes ☐ *If yes*, what type of ship: __________
Nautical miles other ship diverted: __________

Immediate destination of patient?[2] Name of ship/port: __________ Nautical miles from own ship: ________
Mode of patient transport (**check one**) Helo ☐ Fixed-wing ☐ Boat/launch ☐ Return to port ☐ High line ☐
Was main purpose for transport to MEDEVAC? No ☐ Yes ☐

Final destination of patient?[3] Name of ship/port: __________ Nautical miles from own ship: ________
Mode of patient transport (**check one**) Helo ☐ Fixed-wing ☐ Boat/launch ☐ Return to port ☐ High line ☐
Was main purpose for transport to MEDEVAC? No ☐ Yes ☐

Was patient returned to ship?[4] No ☐ Yes ☐ *If yes*, give date (mm/dd/yy):____ /_____ /____

Could TM have facilitated decision on need to MEDEVAC? No ☐ Yes ☐ *If yes*, how: __________
If yes, check which specific TM capability would have helped: __________
Telephone ☐ FAX ☐ e-mail ☐ Internet ☐ VTC ☐ Teleradiology ☐

Could TM have prevented MEDEVAC? No ☐ Yes ☐ *If yes*, how: __________
If yes, check which specific TM capability would have helped: __________
Telephone ☐ FAX ☐ e-mail ☐ Internet ☐ VTC ☐ Teleradiology ☐

Could MEDEVAC have been delayed with TM? No ☐ Yes ☐ *If yes*, how long: __________
If yes, check which specific TM capability would have helped: __________
Telephone ☐ FAX ☐ e-mail ☐ Internet ☐ VTC ☐ Teleradiology ☐

Could TM have expedited MEDEVAC? No ☐ Yes ☐
If yes, check all that apply: better routing ☐ appropriate referral ☐ other ☐ *specify*: __________
If yes, what specific TM capability (i.e., Internet, VTC) would have helped: __________

Other comments on potential role of TM in this case: __________

____

____

Please duplicate this form to add other MEDEVACs of your *own ship's personnel and embarked Marines.* Attach copies to the survey.

[1] The Center for Naval Analyses will use the SSNs for statistical purposes only, and will not release them to third parties.

[2] If another ship, give name/location. If ashore, give name of facility/location.

[3] Specify CONUS or facility name if O-CONUS.

[4] Specify NOT if didn't return to duty station.

Appendix B: Assigning MEDEVAC savings to individual telemedicine modalities

Table 16 contains the factors for distributing MEDEVAC benefits to individual modalities of TM.

Table 16. Factors for distributing MEDEVAC benefits to individual TM modalities

	E-mail and internet	Phone and fax	VTC	Teleradiology
Amphibious ships	0.378	0.162	0.216	0.243
Small ships	0.261	0.174	0.152	0.413
Submarines	0.571	0.286	0.143	0.000

Appendix C: Medical encounter evaluation form

We asked the panel of experts to evaluate the potential impact of TM on a sample of medical encounters from the SAMS database. We generated an evaluation form for each encounter (see example below).

Case Number: 6 **Ship:** MCM13 **ICD9 Code:** 813.4

Subjective text:
19 y.o. cauc male with c/o pain to left wrist x 2wk.
pt states he fell when playing with his girlfrinds children 2 wks ago. Did not seek medical attention at the time since he thought it would get better. denies LOC, hearing any popping, or deformity. States it "swelled up, but did get brused." Denies any other complaints

Objective text:
WD, WD CAUC MALE, IN NAD, VS NOTED A&O X3
Left wrist has slight edema without crepitus, eccymosis, eryethema, or deformity. there is some point tenderness to the medial aspect of the wrist. Distal pulses are 2+, and capillary refill is <2sec. ROM is intact, but exhibits tenderness. No other clinical findins noted.

Assessment:
FRACTURED ULNA, DISTAL END

Plan:
1) X-RAY WRIST AND FOR ARM SERIES: FXOF THE ULNA 31OCT95 WWC
2) SEND TO BMC INGLESIDE, TX FOR EVALUATION.

Disposition:
Referred to another ship or MTF ashore

If referred,
Medical facility: BMC INGELSINDE, TX
Mode of transportation:

Estimated light duty/no duty days:

If Telemedicine had been available, might it have enhanced delivery of care to the patient?
Yes ☐ No ☐. If yes, check all TM capabilities that apply: Telephone ☐ Fax ☐ e-mail ☐ Internet ☐ VTC ☐ Teleradiology ☐

Number of light duty days saved with: Telephone___ Fax___ e-mail___ Internet___ VTC___ Teleradiology___
Number of no duty days saved with: Telephone___ Fax___ e-mail___ Internet___ VTC___ Teleradiology___

From consumer's perspective, which non-digitized instruments, if you had them, would have made a TM consult unnecessary?
Dermascope ☐ Endoscope ☐ Ophthalmoscope ☐ Otoscope ☐ Stethoscope ☐ Ultrasound ☐ X-ray ☐ Defibrillator/EKG ☐

From consultant's perspective, which digitized instruments would be needed for a TM consult to be useful?
Dermascope ☐ Endoscope ☐ Ophthalmoscope ☐ Otoscope ☐ Stethoscope ☐ Ultrasound ☐ X-ray ☐ Defibrillator/EKG ☐

Appendix D: Aircraft flight and ship steaming costs

Table 17 contains the marginal cost of a flight hour for helicopters and fixed-wing aircraft by aircraft model. Table 18 contains the marginal cost of steaming hours for all active fleet ships. We used these figures to estimate the fuel and maintenance cost of a MEDEVAC.

Table 17. Cost of a flight hour (in 1995 dollars, by aircraft type)[a]

				Cost per hour			
Aircraft type	Model	Flight hours	Fleet[b]	Fuel	DLR[c]	Maintenance	Total
Fixed-wing[d]							
Carrier-based	C-2A	6,818	L	$306	$605	$427	$1,338
Land-based	P-3C	593	L	565	615	419	1,599
Carrier-based	C-2A	8,000	P	313	705	549	1,567
Land-based	EP-3E	4,500	P	560	1,120	432	2,112
Helicopter[e]							
Carrier-based	SH-60F	7,240	L	110	437	204	751
Carrier-based	HH-60H	2,911	L	111	501	142	754
DD-, CG-, FF-based	SH-60B	37,686	L	104	725	304	1,134
Logistics ship-based	CH-46D	5,576	L	119	822	352	1,292
Land-based	UH-3H	350	L	116	799	529	1444
Land-based	SH-3H	2,094	L	111	1,523	626	2,261
Land-based	HH-1N	770	L	71	361	215	648
Carrier-based	SH-60F	10,470	P	112	831	377	1,320
Carrier-based	HH-60H	2,989	P	101	905	234	1,241
DD-, CG-, FF-based	SH-60B	41,185	P	104	620	310	1,034
Logistics ship-based	CH-46D	3,592	P	103	683	455	1,242
Land-based	UH-3H	181	P	91	633	238	962
Land-based	SH-3H	434	P	91	633	238	962
Land-based	HH-1N	1,441	P	57	256	953	1,266

a. Source: [2].
b. L: Atlantic; P: Pacific.
c. Aviation depot-level repairables.
d. Fleet air support squadrons with fleet logistics (carrier-based) and fleet air reconnaissance (land-based) missions.
e. Tactical air and staff (carrier-, DD-, CG-, and FF-based) and fleet air support with logistics, utility, and fleet training missions (ship-based) and organic sealift missions (land-based).

Table 18. Cost of a steaming hour (in 1995 dollars, by ship)[a]

UIC	Ship name	Type	Fleet	Steam hours[b]	Cost[c]
04648	SAMUEL GOMPERS	AD	P	4956	$546
05837	PUGET SOUND	AD	L	3132	589
21046	YELLOWSTONE	AD	L	1956	896
21098	SHENANDOAH	AD	L	5108	531
05839	BUTTE	AE	L	4854	395
20111	SANTA BARBARA	AE	L	2856	494
20112	MOUNT HOOD	AE	P	5756	474
20114	SHASTA	AE	P	3290	488
20115	MOUNT BAKER	AE	L	2464	543
20245	KISKA	AE	P	6109	511
07172	LA SALLE	AGF	L	3958	1747
07194	CORONADO	AGF	P	1830	614
20861	CIMARRON	AO	P	4526	598
20862	MONONGAHELA	AO	L	4222	731
21007	MERRIMACK	AO	L	2882	531
21048	WILLAMETTE	AO	P	2334	636
21049	PLATTE	AO	L	4275	517
05832	SACRAMENTO	AOE	P	6255	865
05833	CAMDEN	AOE	P	2403	1080
05848	SEATTLE	AOE	L	6087	1099
20120	DETROIT	AOE	L	4577	1056
21839	SUPPLY	AOE	L	1676	1388
20125	KALAMAZOO	AOR	L	4477	819
20248	ROANOKE	AOR	P	3393	582
21245	SAFEGUARD	ARS	P	2465	272
21467	GRASP	ARS	L	1716	314
21468	SALVOR	ARS	P	2549	287
21441	GRAPPLE	ARS	L	3386	146
04696	HOLLAND	AS	P	2777	535
04697	SIMON LAKE	AS	L	3069	647
05851	L Y SPEAR	AS	L	1995	637
21118	MCKEE	AS	P	1331	794
20151	EDENTON	ATS	L	3716	164
20153	BEAUFORT	ATS	P	2551	192
20154	BRUNSWICK	ATS	P	4257	132
21281	TICONDEROGA	CG	L	6044	1017
21225	YORKTOWN	CG	L	4987	902
21295	VINCENNES	CG	P	5080	825

Table 18. Cost of a steaming hour (in 1995 dollars, by ship)[a] (continued)

UIC	Ship name	Type	Fleet	Steam hours[b]	Cost[c]
21296	VALLEY FORGE	CG	P	5783	953
21345	BUNKER HILL	CG	P	4593	1397
21388	LEYTE GULF	CG	L	6943	771
21389	SAN JACINTO	CG	L	3439	1198
21428	LAKE CHAMPLAIN	CG	P	5542	1055
21429	PHILIPPINE SEA	CG	L	3781	941
21447	PRINCETON	CG	P	6219	1053
21449	NORMANDY	CG	L	4667	1237
21450	MONTEREY	CG	L	4401	1330
21451	CHANCELLORSVILLE	CG	P	5239	571
21623	COWPENS	CG	P	3634	1294
21624	GETTYSBURG	CG	L	6557	1002
21625	CHOSIN	CG	P	5221	1227
21656	HUE CITY	CG	L	6776	956
21657	SHILOH	CG	P	3335	1109
21658	ANZIO	CG	L	5826	1040
21684	VICKSBURG	CG	L	4390	953
21827	LAKE ERIE	CG	P	5020	1402
21828	CAPE ST GEORGE	CG	L	6198	955
21829	VELLA GULF	CG	L	5665	916
21830	PORT ROYAL	CG	P	3313	1180
20541	CALIFORNIA	CGN	P	3858	561
20669	SOUTH CAROLINA	CGN	L	4075	779
20624	MISSISSIPPI	CGN	L	5167	721
20807	ARKANSAS	CGN	P	1226	1150
03362	INDEPENDENCE	CV	P	4968	4500
03363	KITTY HAWK	CV	P	3878	4830
03364	CONSTELLATION	CV	P	5317	3610
03366	AMERICA	CV	L	5472	3887
03365	ENTERPRISE	CVN	L	5160	749
03369	DWIGHT 0 EISENHOWER	CVN	L	8760	728
20993	CARL VINSON	CVN	P	4069	3081
21247	THEODORE ROOSEVELT	CVN	L	8760	1114
21412	GEORGE WASHINGTON	CVN	L	2175	3016
20576	KINKAID	DD	P	4533	1570
20586	HEWITT	DD	P	3600	1039
20587	ELLIOT	DD	P	5403	884
20588	ARTHUR W RADFORD	DD	L	2597	1129

Table 18. Cost of a steaming hour (in 1995 dollars, by ship)[a] (continued)

UIC	Ship name	Type	Fleet	Steam hours[b]	Cost[c]
20589	PETERSON	DD	L	5808	734
20590	CARON	DD	L	4527	839
20591	DAVID R RAY	DD	P	6062	887
20598	OLDENDORF	DD	P	2918	1312
20599	JOHN YOUNG	DD	P	1939	1663
20600	COMTE DE GRASSE	DD	L	4211	682
20601	O'BRIEN	DD	P	5835	745
20602	MERRILL	DD	P	6432	843
20603	BRISCOE	DD	L	1505	1437
20604	STUMP	DD	L	2999	998
20611	CONOLLY	DD	L	4536	794
20613	JOHN HANCOCK	DD	L	2239	1227
20615	JOHN RODGERS	DD	L	6552	726
20833	HARRY W HILL	DD	P	3090	1192
20834	O'BANNON	DD	L	5352	859
20836	DEYO	DD	L	4841	893
20837	INGERSOLL	DD	P	3483	872
20838	FIFE	DD	P	5549	1034
21416	HAYLER	DD	L	3081	996
21487	ARLEIGH BURKE	DDG	L	6098	940
21660	BARRY	DDG	L	3667	1179
21313	JOHN PAUL JONES	DDG	P	5885	877
21640	CURTIS WILBUR	DDG	P	3353	1216
21685	STOUT	DDG	L	3863	681
21686	JOHN S MCCAIN	DDG	P	4102	742
21436	KIDD	DDG	L	6299	893
21437	CALLAGHAN	DDG	P	2311	1531
21438	SCOTT	DDG	L	4462	1108
21439	CHANDLER	DDG	P	3294	1167
21032	MCINERNEY	FFG	L	4145	506
20977	JACK WILLIAMS	FFG	L	4044	455
20979	GALLERY	FFG	L	5452	608
21053	BOONE	FFG	L	3607	766
21054	STEPHEN W GROVES	FFG	L	3028	311
21055	REID	FFG	P	4029	483
21056	STARK	FFG	L	4057	602
21057	JOHN L HALL	FFG	L	5406	429
21058	JARRETT	FFG	P	4260	541

Table 18. Cost of a steaming hour (in 1995 dollars, by ship)[a] (continued)

UIC	Ship name	Type	Fleet	Steam hours[b]	Cost[c]
21059	AUBREY FITCH	FFG	L	4595	467
21103	UNDERWOOD	FFG	L	3629	432
21104	CROMMELIN	FFG	P	3339	619
21105	CURTS	FFG	P	3901	685
21106	DOYLE	FFG	L	2788	641
21107	HALYBURTON	FFG	L	5739	462
21108	MC CLUSKY	FFG	P	4558	631
21109	KLAKRING	FFG	L	4011	537
21110	THACH	FFG	P	2808	619
21197	DEWERT	FFG	L	3818	608
21198	RENTZ	FFG	P	5409	504
21199	NICHOLAS	FFG	L	5059	493
21200	VANDERGRIFT	FFG	P	4908	500
21201	ROBERT G BRADLEY	FFG	L	4996	518
21231	TAYLOR	FFG	L	3565	475
21232	GARY	FFG	P	3959	448
21234	HAWES	FFG	L	5604	455
21235	FORD	FFG	P	2542	916
21236	ELROD	FFG	L	2592	796
21350	SIMPSON	FFG	L	3058	745
21351	REUBEN JAMES	FFG	P	2256	810
21352	SAMUEL B ROBERTS	FFG	L	4297	443
21390	KAUFFMAN	FFG	L	6228	477
21391	RODNEY M DAVIS	FFG	P	4872	556
21430	INGRAHAM	FFG	P	5568	503
05840	BLUE RIDGE	LCC	P	4656	781
20001	MOUNT WHITNEY	LCC	L	3794	820
20550	TARAWA	LHA	P	3645	1867
20633	BELLEAU WOOD	LHA	P	5339	1702
20725	NASSAU	LHA	L	5271	1423
20748	PELELIU	LHA	P	2856	1625
21560	WASP	LHD	L	5208	1616
21533	ESSEX	LHD	P	4750	1541
21700	KEARSARGE	LHD	L	6135	1359
07175	AUSTIN	LPD	L	3207	555
07176	OGDEN	LPD	P	5003	752
07177	DULUTH	LPD	P	2931	682
07181	CLEVELAND	LPD	P	3375	733

Table 18. Cost of a steaming hour (in 1995 dollars, by ship)[a] (continued)

UIC	Ship name	Type	Fleet	Steam hours[b]	Cost[c]
07182	DUBUQUE	LPD	P	4434	707
07183	DENVER	LPD	P	2997	675
07184	JUNEAU	LPD	P	4591	771
07195	SHREVEPORT	LPD	L	5847	580
07196	NASHVILLE	LPD	L	6351	571
07200	TRENTON	LPD	L	3117	550
07201	PONCE	LPD	L	5423	533
07178	GUAM	LPH	L	2775	898
07202	NEW ORLEANS	LPH	P	4896	628
07203	ANCHORAGE	LSD	P	2614	785
20012	PORTLAND	LSD	L	2546	773
20013	PENSACOLA	LSD	L	6115	468
20014	MOUNT VERNON	LSD	P	4788	672
20015	FORT FISHER	LSD	P	4846	579
21218	WHIDBEY ISLAND	LSD	L	4058	508
21639	GERMANTOWN	LSD	P	5143	409
21400	FORT MCHENRY	LSD	P	3731	432
21422	GUNSTON HALL	LSD	L	4813	382
21452	COMSTOCK	LSD	P	4369	479
21562	TORTUGA	LSD	L	3359	444
21530	RUSHMORE	LSD	P	2856	562
21531	ASHLAND	LSD	L	4568	390
21404	SENTRY	MCM	L	1739	516
21405	CHAMPION	MCM	L	1094	634
21406	GUARDIAN	MCM	L	3174	261
21427	DEVASTATOR	MCM	L	1350	422
21453	PATRIOT	MCM	L	4094	266
21455	SCOUT	MCM	L	1242	692
21456	PIONEER	MCM	L	3251	160
21457	WARRIOR	MCM	L	3442	229
21454	GLADIATOR	MCM	L	2843	300
21901	DEXTROUS	MCM	L	1746	249
21836	OSPREY	MHC	L	901	315
21036	OHIO	SSBN	P	5395	333
21038	FLORIDA	SSBN	P	5395	595
21039	GEORGIA	SSBN	P	5395	142
21040	HENRY M JACKSON	SSBN	P	5395	215
21041	ALABAMA	SSBN	P	5395	161

Table 18. Cost of a steaming hour (in 1995 dollars, by ship)[a] (continued)

UIC	Ship name	Type	Fleet	Steam hours[b]	Cost[c]
21042	ALASKA	SSBN	P	5395	146
21043	NEVADA	SSBN	P	5395	194
21044	TENNESSEE	SSBN	L	5395	574
21045	PENNSYLVANIA	SSBN	L	5395	216
21365	WEST VIRGINIA	SSBN	L	5395	234
21433	KENTUCKY	SSBN	L	5395	233
21460	MARYLAND	SSBN	L	5395	200
21461	NEBRASKA	SSBN	L	5395	212
21682	RHODE ISLAND	SSBN	L	5395	179
05131	WHALE	SSN	P	5395	133
05132	TAUTOG	SSN	P	5395	232
05713	KAMEHAMEHA	SSN	P	5395	121
05716	JAMES K POLK	SSN	L	5395	172
05133	GRAYLING	SSN	L	5395	339
05134	POGY	SSN	P	5395	164
05136	SUNFISH	SSN	L	5395	189
05139	PUFFER	SSN	P	5395	186
05141	SAND LANCE	SSN	L	5395	223
05149	BERGALL	SSN	P	5395	292
05150	SPADEFISH	SSN	L	5395	231
05152	FINBACK	SSN	L	5395	224
05146	NARWHAL	SSN	L	5395	128
05153	PINTADO	SSN	P	5395	103
05154	FLYING FISH	SSN	P	5395	169
05155	TREPANG	SSN	L	5395	179
05723	BLUEFISH	SSN	P	5395	283
05724	BILLFISH	SSN	L	5395	152
20041	ARCHERFISH	SSN	L	5395	158
20043	WILLIAM H BATES	SSN	P	5395	152
20044	BATFISH	SSN	L	5395	217
20045	TUNNY	SSN	P	5395	256
20346	CAVALLA	SSN	P	5395	144
20350	L MENDEL RIVERS	SSN	L	5395	108
20785	GROTON	SSN	L	5395	257
20786	BIRMINGHAM	SSN	P	5395	197
20787	NEW YORK CITY	SSN	P	5395	156
20788	INDIANAPOLIS	SSN	P	5395	223
20882	BREMERTON	SSN	P	5395	167

Table 18. Cost of a steaming hour (in 1995 dollars, by ship)[a] (continued)

UIC	Ship name	Type	Fleet	Steam hours[b]	Cost[c]
20811	DALLAS	SSN	L	5395	151
20826	LA JOLLA	SSN	P	5395	185
20827	PHOENIX	SSN	L	5395	269
20830	BOSTON	SSN	L	5395	257
20831	BALTIMORE	SSN	L	5395	312
20832	CITY OF CORPUS CHRISTI	SSN	L	5395	182
21001	ALBUQUERQUE	SSN	L	5395	295
20884	MINNEAPOLIS-SAINT PAUL	SSN	L	5395	181
20885	HYMAN G RICKOVER	SSN	L	5395	306
20886	AUGUSTA	SSN	L	5395	222
20887	SAN FRANCISCO	SSN	P	5395	182
20888	ATLANTA	SSN	L	5395	301
20994	HOUSTON	SSN	P	5395	125
20995	NORFOLK	SSN	L	5395	218
20996	BUFFALO	SSN	P	5395	269
21023	SALT LAKE CITY	SSN	P	5395	164
21024	OLYMPIA	SSN	P	5395	205
21025	HONOLULU	SSN	P	5395	353
21029	PROVIDENCE	SSN	L	5395	220
21030	PITTSBURGH	SSN	L	5395	254
21101	KEY WEST	SSN	L	5395	339
21102	OKLAHOMA CITY	SSN	L	5395	283
21367	HELENA	SSN	P	5395	235
21411	NEWPORT NEWS	SSN	L	5395	183
21312	SAN JUAN	SSN	L	5395	219
21413	PASADENA	SSN	P	5395	245
21462	ALBANY	SSN	L	5395	325
21463	TOPEKA	SSN	P	5395	165
21368	MIAMI	SSN	L	5395	117
21464	SCRANTON	SSN	L	5395	250
21465	ALEXANDRIA	SSN	L	5395	123
21466	ASHEVILLE	SSN	P	5395	483
21605	JEFFERSON CITY	SSN	P	5395	126
21690	ANNAPOLIS	SSN	L	5395	351
21691	SPRINGFIELD	SSN	L	5395	149
21692	COLUMBUS	SSN	P	5395	137

Table 18. Cost of a steaming hour (in 1995 dollars, by ship)[a] (continued)

UIC	Ship name	Type	Fleet	Steam hours[b]	Cost[c]
21693	SANTA FE	SSN	P	5395	140
21761	BOISE	SSN	L	5395	305
21762	MONTPELIER	SSN	L	5395	267
21764	HAMPTON	SSN	L	5395	243

a. Source: [3].

b. Includes hours underway, not underway, and in cold iron.

c. Includes the cost per hour of variable inputs including ship petroleum, oil, and lubricants as well as repair parts. Also includes direct depot maintenance labor and material as well as non-scheduled repair labor, and non-scheduled repair material.

Appendix E: Assigning benefits and costs to telemedicine modalities

Telemedicine "consumers" on the panel of experts selected medical encounters in which they would initiate a consult with TM "providers" (physicians aboard large platforms and land-based specialists). For each of these encounters, the members of the panel (TM consumers and providers) assessed the potential for the following:

- Returning patients to full duty more quickly
- Enhancing delivery of care
- The need for peripheral digitized instruments.

We now explain how we assigned the benefits and costs of TM to each modality—e-mail and internet, telephone and fax, VTC, and teleradiology.

Man-days saved

Providers and consumers on the panel of experts estimated the number of no-duty and light-duty days that each TM consult would save. They selected the modalities of TM that would apply. We assigned benefits and costs to specific modalities of TM depending on their selection.

The panel selected only one TM modality

In cases where the panel selected only one TM modality, we assigned all the savings and costs to that specific modality.

The panel selected more than one modality

If the panel selected more than one modality of TM, we assigned the benefits of TM depending on whether the modalities are substitutes or complements.

The modalities are substitutes

In this case, we assigned the savings and costs to the least costly modality. We assumed that, given a choice between substitute modalities of TM, shipboard medical staff would opt for the least costly modality that would enable a successful consult. The modalities that could serve as substitutes, ranked from least costly to most costly, are e-mail and internet, telephone and fax, and VTC.

The modalities are complements

When the panel selected teleradiology among other modalities of TM, we treated the other modalities as complementary to teleradiology. This is because teleradiology works in conjunction with the other modalities to transmit the results from the consult. In cases where the transmission of an X-ray is needed, teleradiology would produce the digital image, and another modality would send it off the ship. In this case, we assigned the savings to teleradiology and the costs to both teleradiology and the other modality.

In those cases in which the panel selected both e-mail/internet and telephone/fax, in addition to teleradiology, we again assumed that the staff would opt for the least costly modality among substitutes. In this case, we assigned the cost to e-mail and internet, as well as to teleradiology.

Similarly, in those cases in which the panel selected teleradiology, VTC, and either e-mail/internet or telephone/fax, we assigned the savings to teleradiology. We assigned the costs to either the e-mail/internet package or the telephone/fax package. That is, we assumed that the onboard medical staff would use e-mail or telephone to transmit diagnostic readings rather than the more expensive VTC.

In a handful of cases, the panel selected teleradiology and VTC only. This choice applies to cases where an X-ray needed evaluation, but

the patient had a traumatic injury that required visual evaluation. In these cases, we divided the savings between the two modalities in proportion to their relative contribution to the potential savings. We assigned the cost to both VTC and teleradiology.

Enhancement in the delivery of care

The panel assessed the cases in which a TM consult would have resulted in better quality of care. They selected the TM modalities that applied. Our methodology for crediting individual modalities with quality of care enhancements is very similar to the one we applied to the distribution of man-day savings.

The panel selected only one TM modality

In cases in which the panel selected only one modality to enhance quality of care, we credited that modality with the benefit.

The panel selected more than one TM modality

Modalities are substitutes

Where the panel selected more than one modality, and the modalities are substitutes, we credited the least costly modality with the enhancement of care. Again, the modalities that could potentially serve as substitutes, ranked from least costly to most costly, are e-mail and internet, telephone and fax, and VTC.

Modalities are complements

When the panel selected teleradiology in addition to other modalities, we treated the other modalities as complementary to teleradiology. We credited teleradiology and the least costly of the other selected modalities with the enhancement of care.

Peripheral digital instruments

There were cases in which the panel indicated that for a TM consult to be useful, one or more of the following digital instruments were needed: dermascope, endoscope, ophthalmoscope, otoscope, stethoscope, ultra-

sound, X-ray, and defibrillator. When added to any of the four modalities of TM, the instruments form a TM "package" or "suite."

In cases in which the panel deemed the instruments necessary, we attributed all savings to the instruments. We did this to determine which instruments would pay for themselves. As with the four modalities of TM, we compared the discounted benefits and costs of the instruments to determine, for each platform, which ones would be cost-effective. We assigned the savings to specific instruments by dividing the man-day savings by the number of instruments deemed necessary for the consult.

Appendix F: Cost of making equipment operational

Table 19 contains the life-cycle cost of getting a notional $100 telemedicine equipment operational.

Table 19. Cost of making $100 equipment operational (five years, in FY 1997 dollars)[a]

	FY97	FY00	FY01	FY02	FY03	FY04	Total
Up front							
Hardware	100	90.7					90.7
Installation		13.6					13.6
Connectivity		9.1					9.1
Training		3.6					3.6
Recurring							
Maintenance		1.8	1.8	1.7	1.6	1.6	8.5
Supplies		4.5	4.4	4.3	4.1	4.0	21.3
Cost after adjustments							146.8

a. Based on NIMIC's methodology, discounted with real interest rate.

Appendix G: Telemedicine equipment prices

Table 20. Price ranges for telemedicine equipment (as of June 1997)

Device	Price range ($)
Modality of telemedicine	
Telephone and fax	200-2,000
Video teleconferencing[a]	4,000-15,000
Teleradiology	900-500,000
Digital peripheral instruments	
Dermascopes	1,200-9,800
Endoscope	4,000-8,000
Ophthalmoscopes	2,450-2,650
Otoscopes	2,700-12,000
Stethoscopes	485-4,850
Ultasound	1,995-45,200
Electrocardiograms	175-100,000
Portable X-ray	7,905-18,400
Stationary X-ray	8,300-36,900

a. Do not include add-on digital instruments.

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